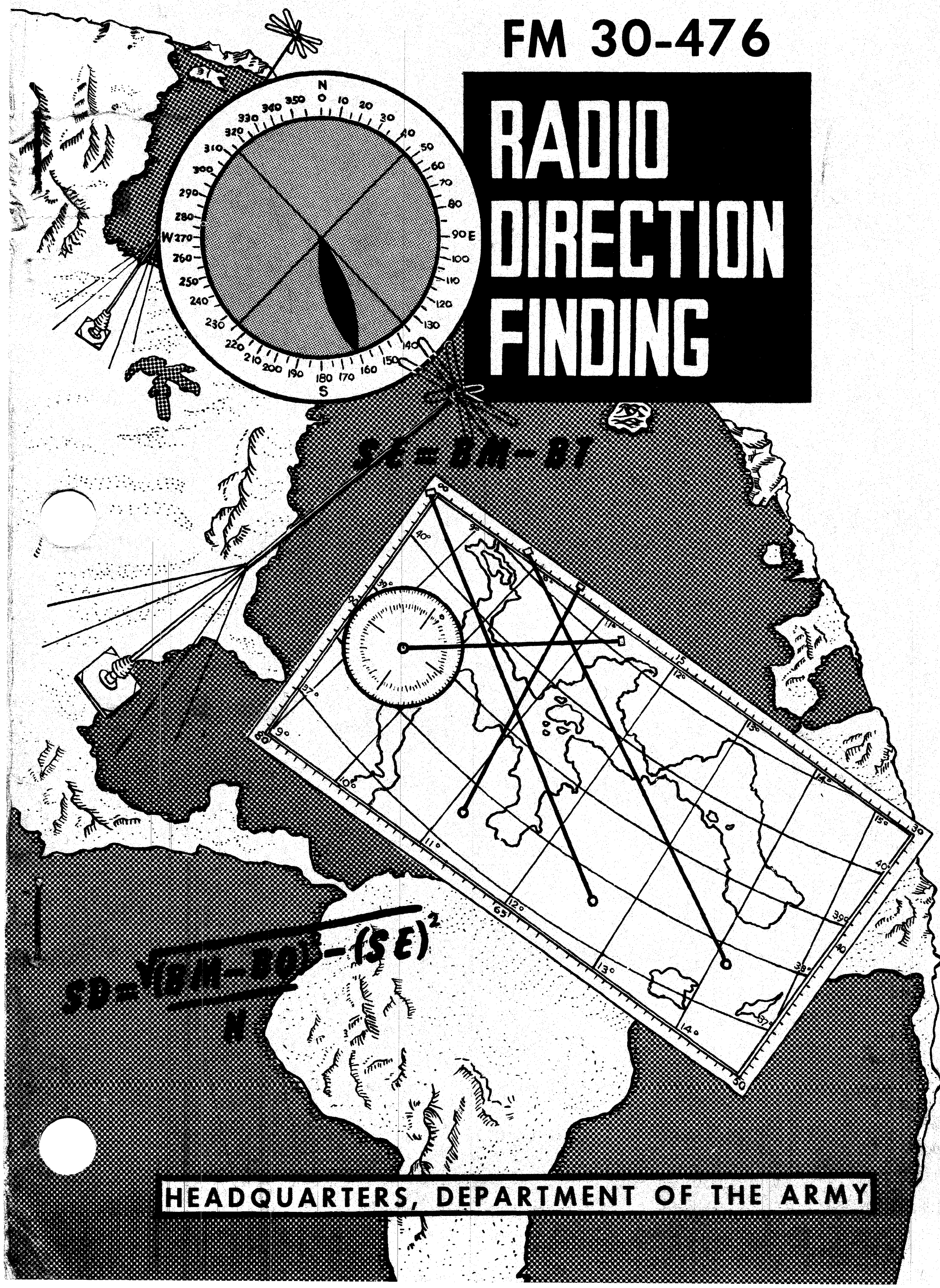
FM 30-476

RADIO DIRECTION FINDING



HEADQUARTERS, DEPARTMENT OF THE ARMY

Field Manual)
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No. 30–476)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 8 April 1977

RADIO DIRECTION FINDING

LIST OF ILLUSTRATIONS

*This manual supersedes TM 32-476, 25 April 1972.

LIST OF TABLES

"The word "he" is intended to include both the masculine and the feminine genders and any exceptions to this will be so noted."

This publication was prepared by the US Army Intelligence School, Fort Devens for use by personnel assigned to US Army tactical support units.

CHAPTER 1

Introduction

1–1. Purpose.

This manual prescribes basic radio Direction-Finding (DF) principles and techniques for personnel responsible for the employment and operation of DF equipment.

1–2. Scope.

This manual includes information pertaining to:

a. Propagation of radio waves.

b. Directional properties and types of directional antennas.

c. Types of DF efforts.

d. DF plotting.

1–3. Comments and Recommendations.

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1–4. Concept of Warfare.

The information contained in this manual is applicable to nonnuclear warfare.

1–5. Definition, Capabilities, and Limitations of Radio Direction Finding.

a. DF is concerned with determining the arrival direction of a radio wave. Unlike an ordinary radio receiver, a DF receiver, with associated equipment, indicates the approximate direction along an imaginary line on which a distant transmitter lies. While information obtained by DF may not always be accurate enough to direct artillery fire, the direction of a distant transmitter can be determined, in most cases, to an accuracy on the order of ± 2 degrees. One DF site can determine only the approximate direction of a distant transmitter. However, by the use of two DF sites, the approximate location of a transmitting antenna can be found. By the use of three DF sites, a fixed location can be found.

b. The theory of DF has remained reasonably static since the early history of the study of electromagnetic wave phenomena. Initially, attempts were made to obtain directional transmissions because early transmitters were relatively low powered and inefficient in their output and receivers were relatively insensitive. Efforts were undertaken to "direct" the transmitted wave toward the receiving device to ensure communications rather than to determine locations. The useful applications of DF were obtained almost simultaneously with the effort to provide directional transmissions.

1–6. Military Use of DF.

DF is extensively used as navigation aids, as sources of signal intelligence, and in electronic warfare support measures.

a. Navigation. As navigational devices, DF equipment is either used alone or in combination with radio communications systems, depending upon the service which is to be provided. Such service includes the positioning, controlling, and homing of ground, sea, and air forces. DF equipment is also used by rescue personnel as an essential part of air-sea rescue. Crash beacons on downed aircraft or disabled ships provide a signal which can be located or "homed-in" on by use of DF equipment.

b. Signal Intelligence. The use of radio in military communications has increased the value of DF in furnishing signal intelligence. Even if a hostile force is extremely careful, his transmissions by radio can be intercepted and the location of his transmitters determined. This information is invaluable when used by traffic analysts in determining order of battle.

c. Electronic Warfare Support Measures. Electronic Warfare Support Measures (ESM) are those actions taken to search for, intercept, locate, record, and analyze radiated electromagnetic energy for the purpose of exploiting such radiations in support of military operations. ESM activities provide the operational information required to conduct Electronic Countermeasures (ECM), Electronic Counter-Countermeasures (ECCM), threat detection, warning, avoidance, target acquisition, and homing.

CHAPTER 2

Wave Propagation Theory

Section I
PROPAGATION OF ELECTROMAGNETIC WAVES

2–1. General.

In order to understand how a radio receiver intercepts or "hears" signals from the atmosphere, a basic introduction to radio waves is necessary. This section describes the nature of radio waves and the basic principles involved in the propagation of radio waves from a transmitting station to a receiver or DF site. Since DF involves determination of the arrival direction of these waves, an understanding of these principles will improve the results obtained with DF equipment. If a more detailed study of wave transmission phenomena is required, additional information may be found in TM 11–666, Antennas and Radio Propagation, and TM 11–665, CW and AM Radio Transmitters and Receivers.

a. The frequency bands and their designators which are detailed in table 2–1 provide the commonly accepted limits of each band. Information which follows in this manual is primarily applicable to the DF effort on frequencies up through the High Frequency (HF) band.

b. Transmissions using frequencies in the Very High Frequency (VHF) and higher bands are identified as line-of-sight transmissions. This type of signal is used in communications and is vulnerable to DF but, since it uses the directwave component of the groundwave (para **2–11**), it is limited in effective range. Section IV of this chapter furnishes additional information concerning higher frequency uses.

Table 2–1. Frequency Ranges and Band Designators

FREQUENCY RANGE	BAND DESIGNATOR
30 to 300 Hertz (Hz)	Extremely Low Frequency (ELF)
300 to 3000 Hz	Voice Frequency (VF)
3 to 300 Kilohertz (kHz)	Very Low Frequency (VLF)
30 to 300 kHz	Low Frequency (LF)
300 to 3000 kHz	Medium Frequency (MF)
3 to 30 Megahertz (MHz)	High Frequency (HF)
30 to 300 MHz	Very High Frequency (VHF)
300 to 3000 MHz	Ultrahigh Frequency (UHF)
3 to 30 Gigahertz (GHz)	Superhigh Frequency (SHF)
30 to 300 GHz	Extremely High Frequency (EHF)

2–2. Electrical Component of Radio Waves.

a. To transmit, an antenna must be coupled to a transmitter through a coil or other electrical device. The electromagnetic wave front, or wave, which is required for transmission consists of an electrical field and a magnetic field, identified in this manual as the E and H field respectively.

b. The analogy of a pebble dropped into a smooth pond or body of water, with the resulting waves or ripples traveling in concentric circles outward from the point of disturbance, has often been used to illustrate radio wave action from a transmitter. The wave front alternately reverses polarity due to changes in the voltage applied to the antenna. Capital A, figure 2–1 illustrates this principle with the electrical lines of force at any given instant showing a positive polarity. Since electrical charges of a like polarity repel one another, these lines of force are illustrated as bowed out but shortening themselves as much as possible to the earth since they cannot expand indefinitely. When the antenna

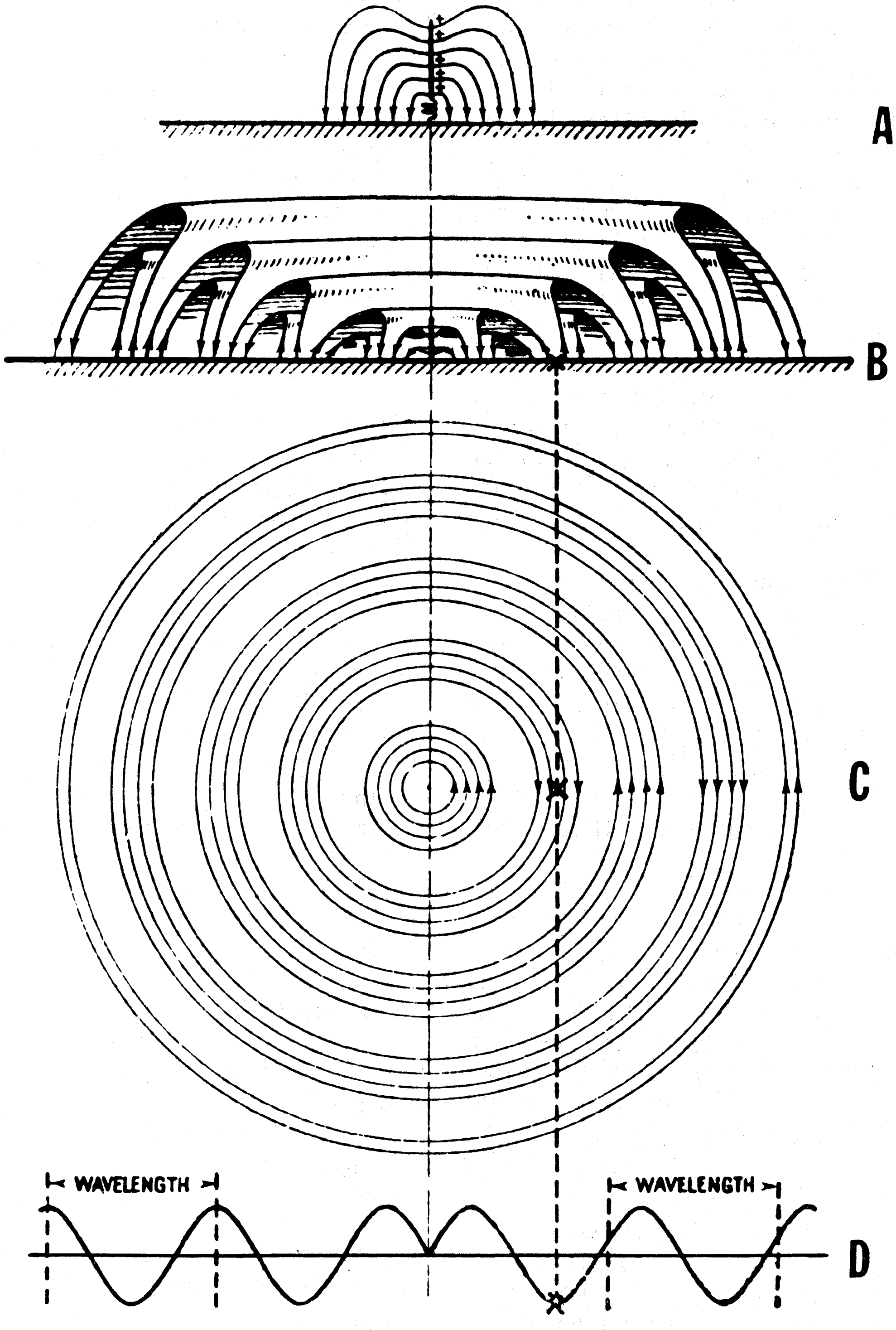


Figure 2–1. Electromagnetic wave radiation from a vertical antenna.

current changes polarity, the electrical field collapses momentarily, builds again, and assumes opposite polarity. The full cycle is illustrated in Capital B, figure 2–1. The arrowheads at the end of each line indicate the force reversing itself alternately. The electrical component of the wave continues to perform in this manner as long as the transmitter is keyed. This reversal of polarity is again observed at Capital C, figure 2–1, by the arrowheads reversing their direction periodically. Capital D, figure 2–1 equates this action to wavelength which is discussed later in this chapter. Shields, reflectors, or other devices may be attached to or installed near a transmitting antenna to make these electromagnetic waves highly directional; however, for this discussion, only omnidirectional transmissions are explained.

c. This manual does not discuss fully the electrical theory associated with electromagnetic wave propagation. To do so would involve an elaborate study of induction, flux fields and densities, right and left hand rules with regard to current flow, and many other details.

2–3. Magnetic Components of Radio Waves.

A magnetic component (H field) that cannot be dissociated from the electrical field at any time exists in the radiated wave. In paragraph **2–2**, the continuing change of polarity, or oscillation, of the transmitted wave was discussed. Thus, oscillating electrical and magnetic fields are produced along the path of wave travel. The frequency of the oscillating fields is the same as the frequency of the antenna current, and the magnitudes of both fields vary continuously with this current. The variations in the magnitude of the electrical component (E field) and those of the magnetic component (H field) are in time phase, so that at every point in space the time-varying magnetic field induces a difference in voltage, which is the electric field. Thus, the varying magnetic field produces a varying electric field, and the varying electric field, through its associated displacement current, sustains the varying magnetic field. Each field supports the other, and neither can be propagated by itself. Figure 2–2 illustrates the interrelationship of the two fields (components). It should be kept in mind that figure 2–2 illustrates only one transverse section of the entire wave front, which fills all the space shown in the figure.

2–4. Wavelength.

The conventional way of illustrating the electrical and magnetic force of any electromagnetic wave is by a sine curve, as in Capital D, figure 2–1. If a wave were visible, it would look like a sine curve, curving above and below a base line. The distance between the forces at maximum intensity in the same direction is known as the wavelength. Wavelength may also be defined as the distance between two points where the forces are identical in intensity and are changing in the same manner. Figure 2–3 is another method of illustrating the various components of the radio wave. Both elements of the wave are present regardless of polarity (which is discussed in section II, this chapter); however, all discussion and illustrations have dealt with the vertical element.

2–5. Frequency.

a. Frequency is the actual number of occurrences in one unit of time of the sine curve illustrated in Capital D, figure 2–1. The frequency of a transmitted wave is measured in Hertz (Hz), Kilohertz (kHz), Megahertz (MHz), or Gigahertz (GHz). Some existing manuals may contain frequency references using Cycles Per Second (c/s), Kilocycles (kc), Megacycles (Mc), or Gigacycles (Gc). The National Bureau of Standards and the Department of Defense (DOD) have adopted

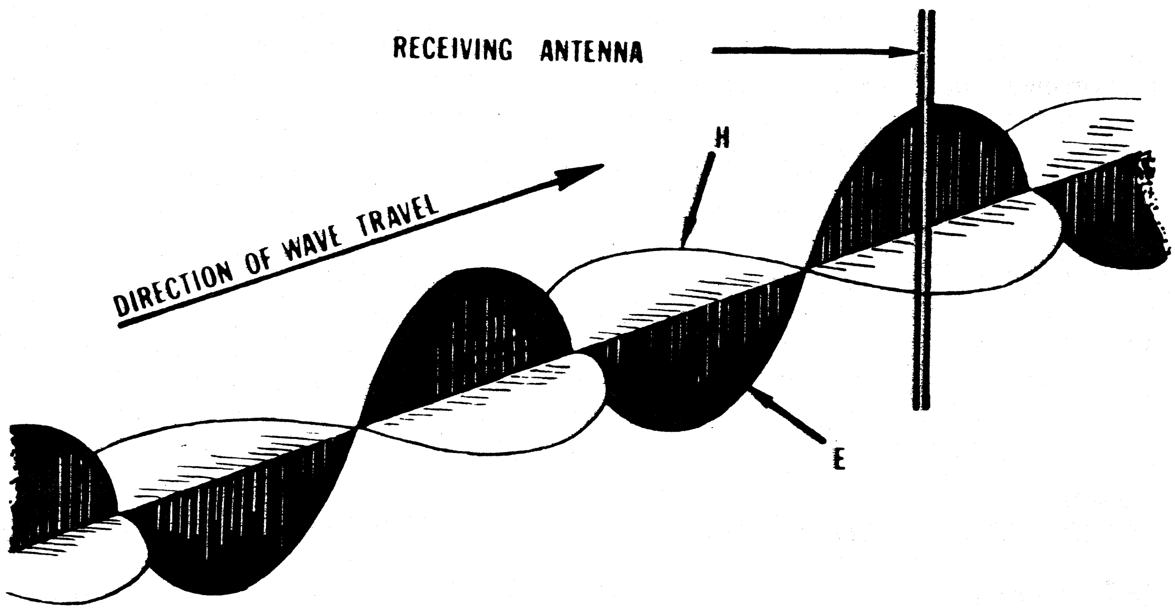


Figure 2–2. E and H fields of a radiated wave.

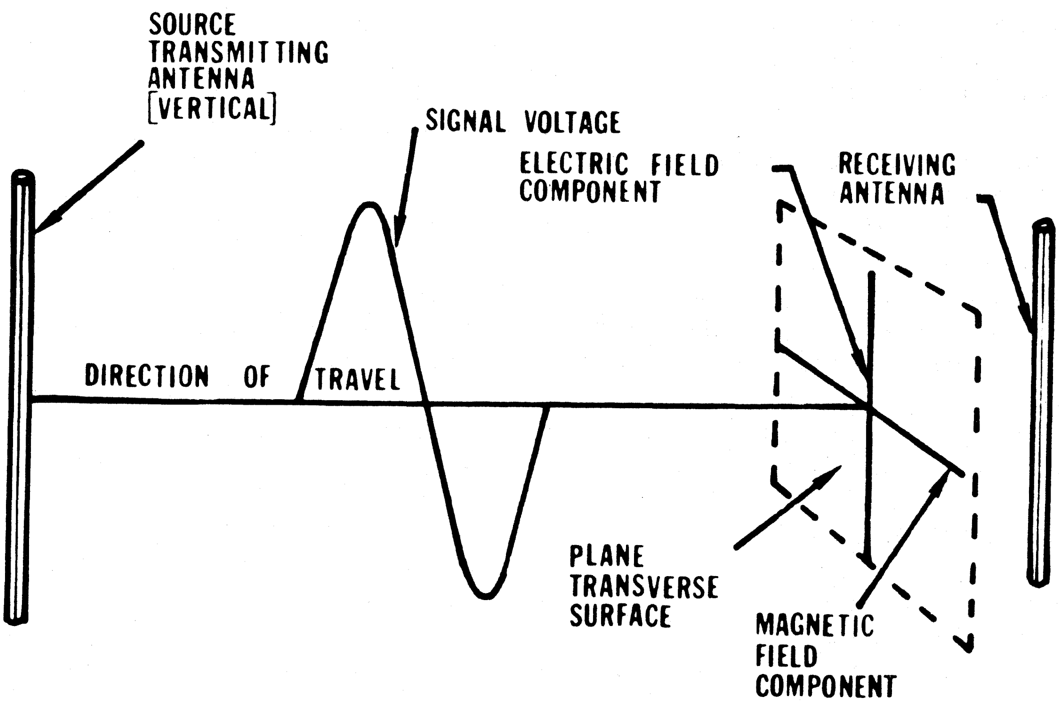


Figure 2–3. Components of an electromagnetic wave.

the term Hertz as the standard method of referring to frequency.

b. A conversion formula for wavelength and frequency is shown below. If the measurement in *Hertz* is known and a conversion to wavelength is desired, apply:

$$\text{Wavelength (meters)} = \frac{300{,}000{,}000^*}{\text{Frequency (Hz)}}$$

If wavelength (in meters) is known and a conversion to frequency (Hz) is desired, apply:

$$\text{Frequency (Hz)} = \frac{300{,}000{,}000}{\text{Wavelength (meters)}}$$

Section II

POLARIZATION OF RADIO WAVES

2–6. General.

Polarization, or the relationship of the different fields in the transmitted wave, may be either vertical, horizontal, or a mutation which adopts portions of the vertical and horizontal. The latter results in a circular or a hybrid form of a wave. This manual will deal primarily with vertical and horizontal polarization. If a whip or other vertical type transmitting antenna is used to propagate radio waves, the transmitted wave is considered to be vertically polarized. If the transmitting antenna is horizontal relative to the ground or earth's surface, the transmitted wave is horizontally polarized. The direction the electric field moves relative to the ground is taken as the reference point and determines the polarization of the wave.

2–7. Vertical Polarization.

Imagine a rope lying reasonably straight on the ground with one end attached firmly to a tree or other support. If the loose end of the rope is raised, tightened, and given a violent up and down motion, a series of undulating "waves" will travel along the rope. Although the rope remains firmly attached and firmly grasped, the movement of the waves up and down, vertical to the ground, can be clearly observed. Radio waves perform in a manner similar to the waves produced along the rope. As long as the E field component of the waves moves up and down with reference to the earth, they are identified as being vertically polarized. Ocean waves are vertically polarized since the wave movement is up and down. There is a definite effect produced by these waves, although there is little horizontal movement of the water through which the wave passes.

2–8. Horizontal Polarization.

If the same rope had a movement applied in a horizontal manner, the waves would be in a horizontal plane and would be called horizontally polarized waves.

2–9. Plane Polarization.

From paragraphs **2–7** and **2–8**, it is easy to imagine taking the same rope and giving it a violent shake in any particular angle relative to the earth resulting in a straight line, not necessarily vertical or horizontal. In all three cases, however, the wave would be polarized along a plane (plane polarized waves), a name given to any system of transverse wave motion which takes place in one plane due to the direction of propagation, whether it be vertical, horizontal, or any intermediate direction.

a. Linear Polarization. Vertical and horizontal polarization, illustrated in figure 2–4 are two examples of a form of polarization known as linear polarization. The term linear means that (except for the 180

*The speed of light in meters per second which is the speed at which radio waves travel.

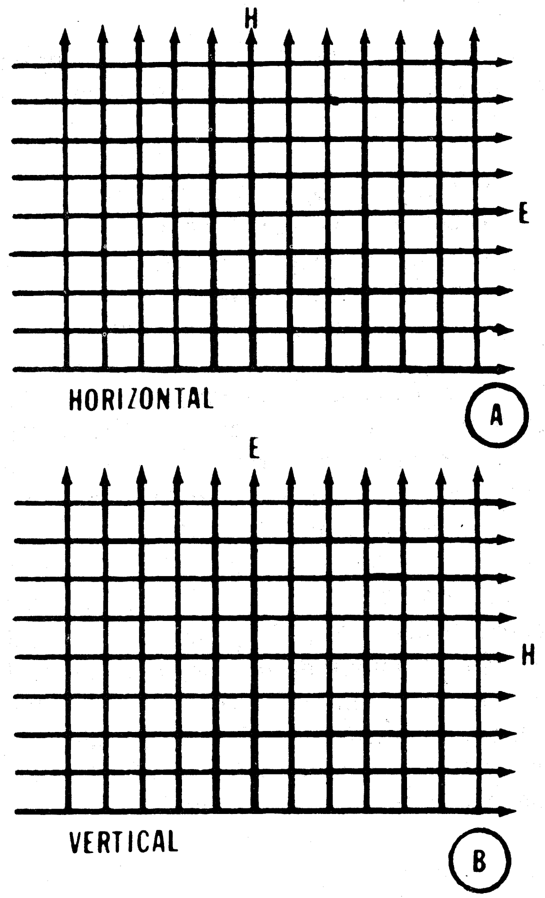


Figure 2–4. Representation of magnetic and electric fields in horizontally and vertically polarized wave fronts.

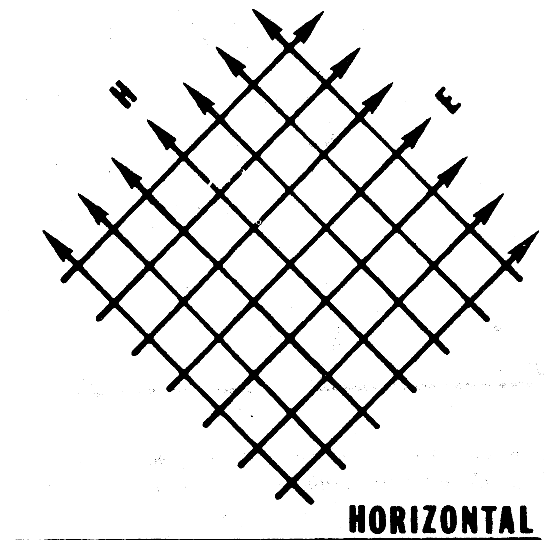


Figure 2–5. Representation of electric and magnetic fields in wave front polarized at an angle to the horizontal.

degree phase reversal during a cycle) the orientation of the electric field does not change. In other words, the electric field of a horizontally polarized wave always remains horizontal, and the electric field of a vertically polarized wave always remains vertical. By various means it is possible to produce a linearly polarized wave at any angle. A linearly polarized wave at an angle of 45 degrees from the horizontal is shown in figure 2–5. One method of producing this direction of polarization is to tilt a horizontally polarized aircraft antenna to a 45 degree angle. Tilting the electric field in this manner serves no useful purpose insofar as radiation in this form is concerned, but it can be used as a starting point for introducing another type of polarization, referred to as circular polarization.

b. Circular Polarization. Assume that an electric field is tilted at a 45 degree angle as shown in figure 2–5 and further assume that by the use of some device it is possible to resolve this field into its horizontal (E_h) and vertical (E_v) components as shown in figure 2–6. These two components would still be in phase; that is, measured at a given point, both E_h and E_v would have the same relative amplitude at any given time. If either component is shifted in phase by 90 degrees, or one quarter wavelength, a new type of polarization becomes possible. If it is assumed that the horizontal component E_h has been retarded 90 degrees in phase, then when E_v has maximum amplitude, E_h is zero, and vice versa. The E vector is shown in figure 2–7 for several different conditions of E_h and E_v. To an observer standing in one spot and able to

"see" the electric field, the field would appear to have a circular motion and a constant amplitude.

AT E_1; E_H = $O,_V$ = MAX POSITION
AT E_2; E_H = E_V, BOTH POSITIVE
AT E_3; E_V = O,E_H = MAX POSITIVE
AT E_4; E_H = O,E_V = MAX POSITIVE
AT E_5; E_V = O,E_H = MAX POSITIVE

c. Elliptical Polarization. In the development of a circularly polarized wave, any attentuation introduced by the phase-shifting device must produce the same effect on both E_h and E_v. If this condition is not obtained, the peak amplitudes of E_h and E_v will not be the same. As a result, the electric field as "seen" by the observer will vary in both amplitude and direction, and will describe an elliptical path. Hence, the resulting polarization is known as elliptical polarization. Two possibilities of elliptical polarization are shown in figure 2–8.

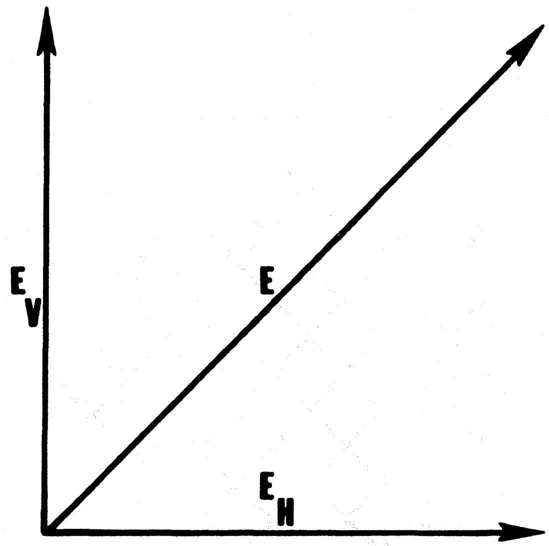


Figure 2–6. Vertical and horizontal components of the electric field in directions other than vertical or horizontal.

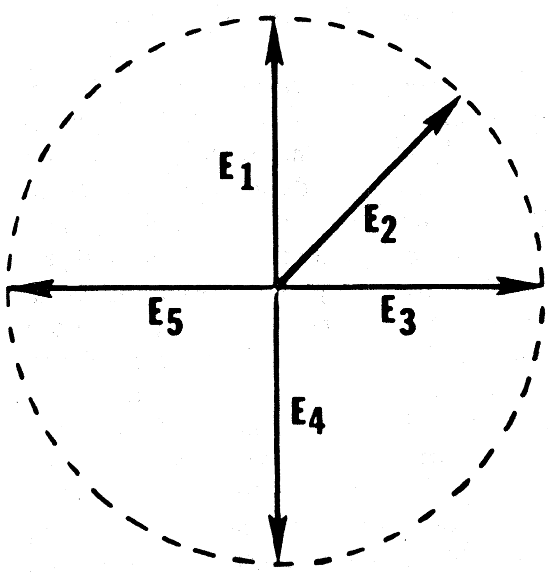


Figure 2–7. Successive directions of the electric field in a circularly polarized electromagnetic field.

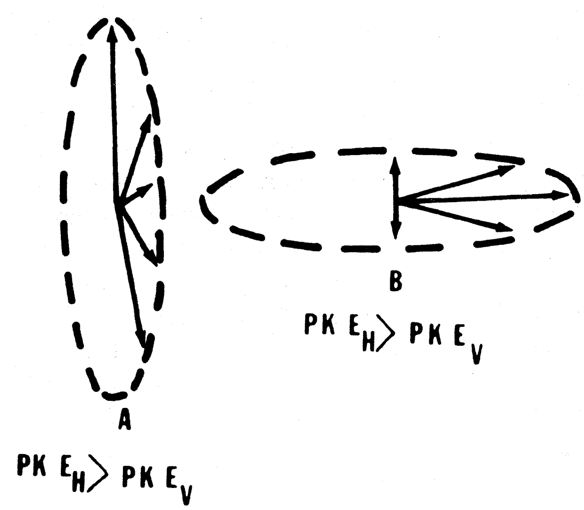


Figure 2–8. Successive directions of the electric field in an elliptically polarized electromagnetic field.

Section III
PROPAGATION FACTORS

2–10. Electrical Phenomena in Radio Wave Propagation.

Radio wave propagation is defined as extending or transmitting electromagnetic energy through space. There are numerous factors affecting radio propagation. Wavelength, frequency, and polarization, which have been discussed previously, are all essential elements of the actual wave. Space, or the medium through which waves travel, contributes or creates additional considerations which personnel engaging in or using DF results must understand.

2–11. Types of Radio Waves.

Radio waves may be classified as either groundwaves or skywaves (fig. 2–9).

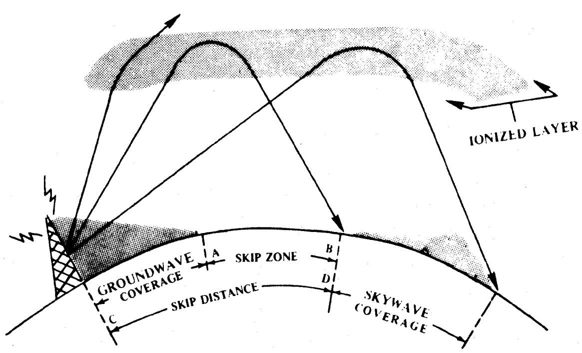


Figure 2–9. Groundwaves and skywaves.

a. Groundwaves are continuously in contact with the earth's surface and do not make use of reflection from the ionosphere. They have a tendency to be refracted and, in some cases, reflected into the lower atmosphere. At frequencies above 1500 kHz, a groundwave is affected very little by the time of day or season. The groundwave loses much of its strength and dissipates energy as it travels over the earth's surface. However, less strength is lost when it travels over water.

b. Skywaves are transmitted upward with respect to the earth's surface. Skywaves would not be useful for communications were it not for the ionosphere, a region of ionized gases in the earth's atmosphere located some 50 to 400 kilometers above the earth's surface. Radio waves approaching the ionosphere at an angle are refracted (para **2–18**) back to earth where they may be detected and used for communications purposes or for DF exploitation. Figure 2–10, similar to figure 2–9, represents the waves that penetrate the ionosphere and are lost for all practical purposes, and also those waves that return to earth for communications use.

2–12. The Ionosphere.

The ionosphere consists of a series of layers of ionized gases which occur at different levels and vary in intensity and height above the earth's surface during the course of the day. An important relationship between radio waves and the ionosphere is that the higher the frequency, the less will be its tendency to bend as it enters the ionized area. Dependent upon ionospheric conditions and the angle of the signal's arrival at the ionosphere, the bending will be so slight that the radio waves will not be sent back to earth, but will continue into space (fig. 2–10).

a. Factors which influence the ionosphere, and therefore its effect on radio waves, are the time of day, the season of the year, solar flares, magnetic storms, and certain manmade disturbances such as atomic detonations. More information may be obtained concerning this phenomena by consulting any standard reference encyclopedia and reading of the efforts of three physicists, Kennely, Heaviside, and Appleton, who were early pioneers in this area.

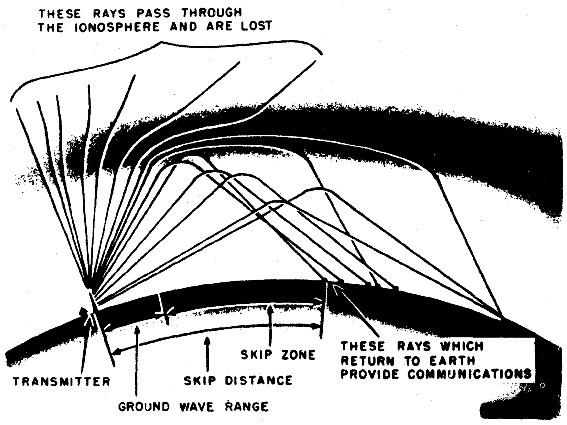


Figure 2–10. Wave penetration.

b. For the purpose of this manual, however, the reader must understand that there are essentially four layers (D, E, F1, and F2) of the ionosphere which affect communications, propagation, and DF.

(1) Some of these layers combine during periods of varying ionization. Exposure of the atmosphere to the sun causes ionization, and the degree of ionization is determined by the duration of exposure. During daylight hours, the ionization reaches a maximum intensity at approximately 400 kilometers above the earth's surface.

(2) To describe the term "varying ionization," it is necessary to briefly discuss the matter which is present in the ionosphere and the mechanics of ionization. Energy in the form of electromagnetic radiation of the proper wavelength and energy is capable of dislodging some loosely bound electrons from their atoms. When this occurs frequently in any gas, it is said to be ionized since it has atoms lacking electrons and free electrons dissociated from any atom. Atoms lacking their normal quota of electrons are called positive ions, and electrons dissociated from any atom are called negative ions. The term ion is, in fact, applied to any elemental particle that has an electric charge. Although a few ions may exist in any gas, external energy must be applied to the atom in order to produce an abundance of ions. Ionization is said to exist when all or a large proportion of the particles in the gas are positive and negative ions. Although external energy may come from many sources, we are primarily interested in the ultraviolet rays the sun constantly gives off which ionize the gas particles of the upper atmosphere. This ionization is not static and recombination takes place continuously. The rate of recombination depends in part upon the density of the gas molecules. The atoms and ions in a gas are in constant motion, and frequent collisions take place. When an electron collides with a positive ion, it may combine with it to form a neutral atom of the gas. The time that it takes for recombination, or deionization, depends on several factors, but principally upon the average distance between the particles of the gas. If only a few particles are present, as in the upper atmosphere, collisions will not occur very frequently, and the particles remain ionized for relatively long periods.

c. Other changes in composition occur (F layers combine), and it becomes a thin layer at an altitude of approximately 270 kilometers. At night, the higher radio frequencies are more likely to penetrate the ionosphere and be lost. Therefore, as a rule, lower communications frequencies are used during the night. Conversely, during the day when the ionization of the atmoshpere is more intense, higher communications frequencies can be used without undue loss of the signal because of penetration of the ionized layer. Changes in the relative proximity of the sun to the earth cause gradual changes in the ionosphere. The longer exposure of the ionosphere to the sun during the summer causes a greater degree of ionization during both night and day. Therefore, higher frequencies may be used for

summer operation. Figure 2–11 presents the approximate heights of the various layers of the ionosphere.

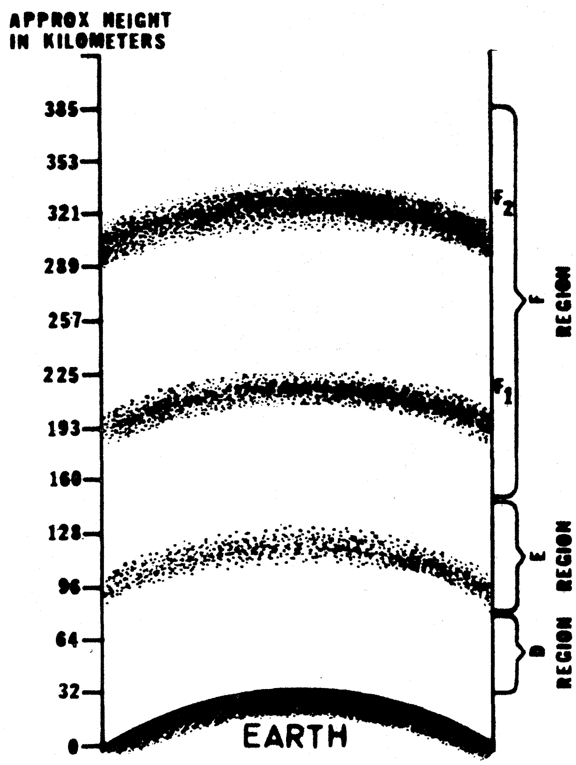


Figure 2–11. Approximate heights of ionospheric layers.

d. Remember, however, that the actual number of layers, their heights above the earth, and the relative intensity of ionization present, all vary from hour to hour, from day to day, from month to month, and from year to year. There are many ionospheric predictions generated to determine the best skywave frequencies over any transmission path at any time of day and for average conditions for the month. Ionospheric prediction information can be obtained from the Bureau of Standards. A pamphlet called the "Monthly Basic Radio Propagation Predictions" can be obtained 3 months in advance from the Central Radio Propagation Laboratories, National Bureau of Standards, Washington, DC 20234. Information regarding radio wave propagation may also be obtained by writing to: Commander, USACEEIA, ATTN: ACCC–CED–RP, Fort Huachuca, AZ 85613.

2–13. The Stratosphere.

The stratosphere is that portion of the earth's atmosphere between the troposphere and the ionosphere. Since the temperature in this region is considered to be almost constant, it is also known as the isothermal region. The stratosphere has little if any effect on radio waves which are transmitted through it, and it is mentioned only to differentiate the three major regions of the earth's atmosphere.

2–14. The Troposphere.

a. The troposphere, which greatly influences communications, is that portion of the earth's atmosphere extending from the surface of the earth to heights of approximately 95–105 kilometers. In transmitting a wave, there are four distinct paths that the wave may take to reach the receiving antenna: direct, reflected, refracted, and tropospheric ducting. The direct and reflected paths shown in figure 2–12, are purposely exaggerated to enable the reader to clearly grasp the differences. The direct path goes directly from the transmitting to the receiving antenna. The reflected path "bounces" off the ionosphere, troposphere, or the surface of the earth at the same angle of arrival and continues to the receiving antenna. The refracted path is the path caused by the bending of the waves in the same manner light waves are bent when seen through water. If the waves are refracted by the earth, the distance they travel is severely limited due to large losses of energy in the form of heat dissipated into the earth's crust. By contrast, those waves refracted by the troposphere may travel great distances.

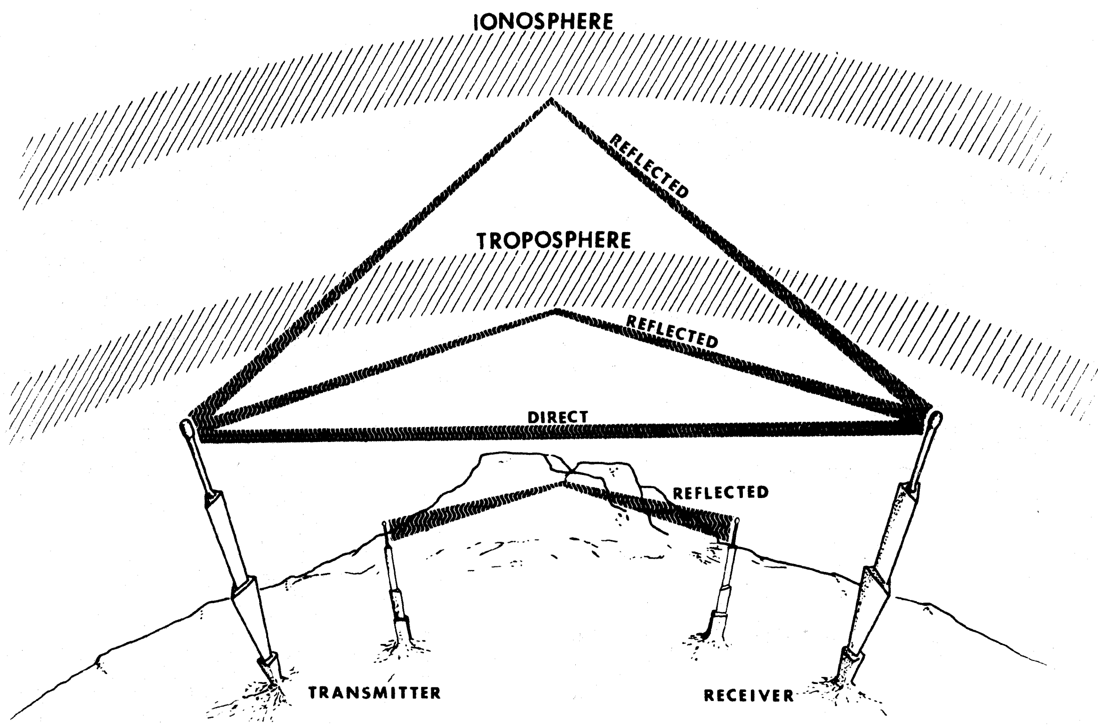


Figure 2–12. Reflected and direct routes for radio waves.

b. The tropospheric path is a combination of reflection, refraction, and certain "channeling" phenomena caused by the humidity and density of the atmosphere. The term tropospheric "scatter" is also widely used for descriptive purposes. The tropospheric wave is that component of the entire wave front which is refracted in the lower atmosphere by relatively steep gradients (rapid changes in respect to height) in atmospheric humidity, and sometimes by steep gradients in atmospheric density and temperature. At heights varying from a few hundred meters to a kilometer or so, huge masses of warm and cold air exist near each other, causing abrupt temperature differences and changes in density. The resulting tropospheric refraction and reflection make communications possible over distances far greater than can be covered by the ordinary groundwave. Depending upon the dielectric constant and the moisture content of the troposphere, the radio waves may be refracted upward or downward, as depicted in figure 2–13. Since the amount of refraction increases as the frequency increases tropospheric refraction is more effective at the higher frequencies, providing more available communications possibilities at 50 MHz and above.

c. One common cause of tropospheric refraction is temperature inversion, which is the result of any of the following: a warm air mass overrunning a colder mass; the sinking of an air mass heated by compression; the rapid cooling of surface air after sunset; and the heating of air above a cloud layer by the

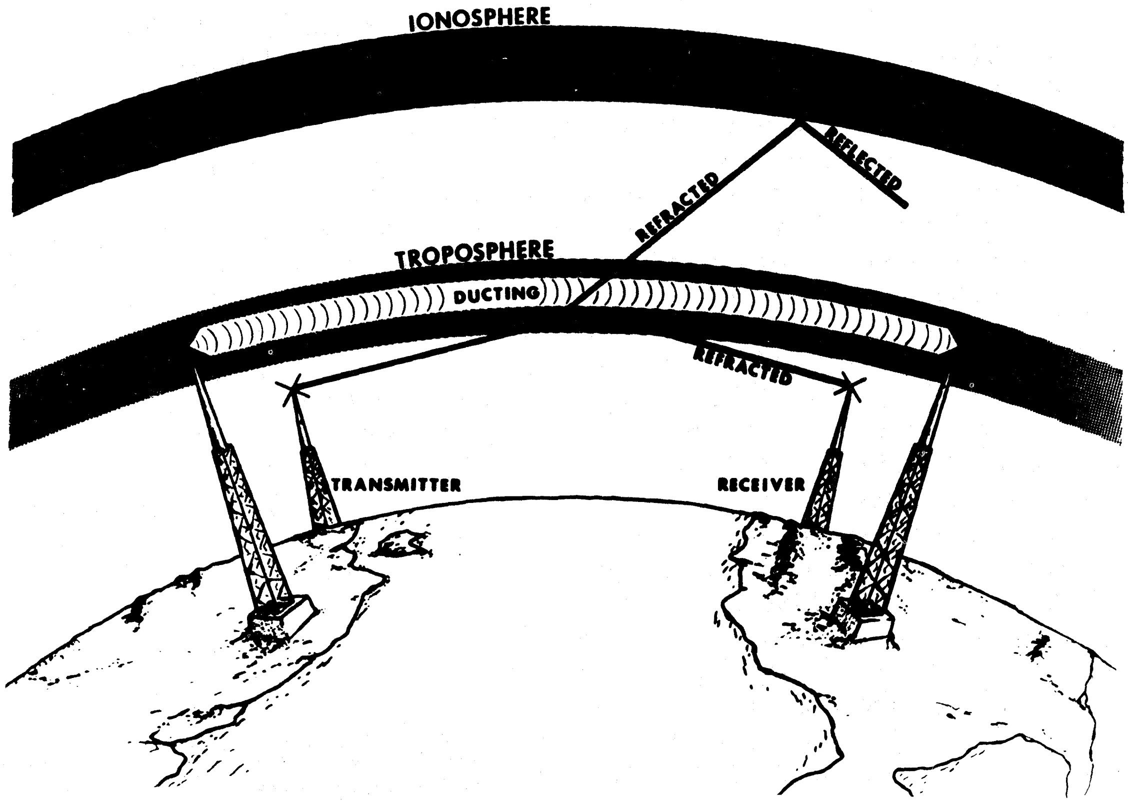


Figure 2–13. Atmospheric ducting and refracted routes for radio waves.

reflection of the sun's rays from the upper surface of the clouds. The effect of tropospheric propagation depends on weather conditions which vary from minute to minute, thus causing fading or variable field intensity. In tropospheric wave communications, the receiving and transmitting antennas should have the same polarization, since the tropospheric wave maintains essentially the same polarization throughout its travel.

2–15. Abnormal Effect of the Troposphere.

a. In the tropics and over large bodies of water, temperature inversions are present almost continuously at heights up to approximately 1,000 meters, particularly from 50 to 150 meters. When the boundary of the inversion is defined sharply, waves traveling horizontally or at very low angles of elevation become trapped by the refracting layer of air and continue to be bent back toward the earth. Figure 2–13 shows how such a trapped wave follows a duct, the upper and lower walls of which are formed by the boundary and the earth. This is the channeling mentioned in paragraph **2–14.** The waves are guided within this duct in much the same manner as in a metallic waveguide, and since attenuation in a waveguide is slight, the energy does not fall off inversely as the square of the distance. Thus, the waves follow the curvature of the

earth for distances far beyond the optical horizon of the transmitter, and in some localities they may consistently reach distances of many thousands of kilometers.

b. Tropospheric ducts also are formed by the waveguiding effect of two layers of air with sharply defined temperature inversions. The refraction from the upper boundary bends the wave down, and the refraction from the lower boundary bends the wave up, effectively trapping the energy within the layer. The height of the duct determines the minimum frequency, and if this height is only a few meters above the surface of the earth, or from boundary to boundary, transmission may be possible only at the UHF or SHF frequencies. Occasionally, the height and the dielectric characteristics of the layer are suitable for VHF transmissions. However, a necessary feature of duct transmission is that the angle of approach of the incident wave be approximately half a degree or less for the wave to be trapped. In addition, both the transmitting and the receiving antennas must be inside the duct if communication is to be established by this means. A transmitting antenna above the duct, as on a tower or promontory, will not operate into the duct, and no signals will be received by the receiving antenna. Moreover, a receiving antenna below a duct will not receive signals from an airplane flying in or above the duct, even though line-of-sight conditions prevail. From this it is apparent that accurate tropospheric propagation predictions are essential to establish reliable communications. Also, it should be obvious that due to the channeling effects of tropospheric returns, this means of communications, if used by unfriendly targets, would have little value to friendly DF efforts. Tropospheric information is included in this manual since supporting communications units make extenisve use of it in normal communications, and the supported commander who receives DF information may, therefore, become particularly attracted to this means of communications. Its value to the DF effort is of little, if any, consequence.

2–16. Influence of Soil Conductivity Relative to Wave Propagation.

A wave front is a surface of equal phase perpendicular to the direction of travel of the wave. As previously discussed, the wave front has been found to contain both electric and magnetic components as it is propagated. Within a few wavelengths of a transmitting antenna, the lines of both magnetic and electric force are appreciably curved. At greater distances the curvature becomes so slight that the network of horizontal and vertical lines becomes, for all practical purposes, a vertical plane presenting a wave front to a receiving antenna. This front is shown diagrammatically in figure 2–14. In

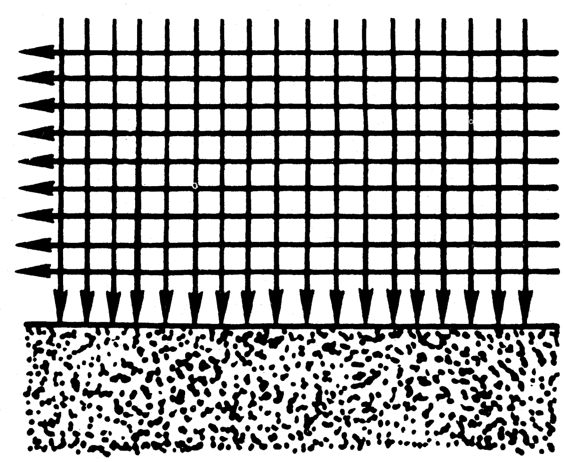


Figure 2–14. Wave front of normally polarized wave.

practice, the plane containing the electric and magnetic forces in the wave, constituting the wave front, is never truly vertical unless the wave is passing over a surface which has infinite conductivity, such as salt water, or is traveling in free space. The horizontal electric

force in a wave, in the direction of its travel, can lead to some confusion and is, therefore, worth consideration. To propose an extreme case, imagine a wave traveling over a perfect conducting surface, with the arrow AB in figure 2–15 representing the vertical

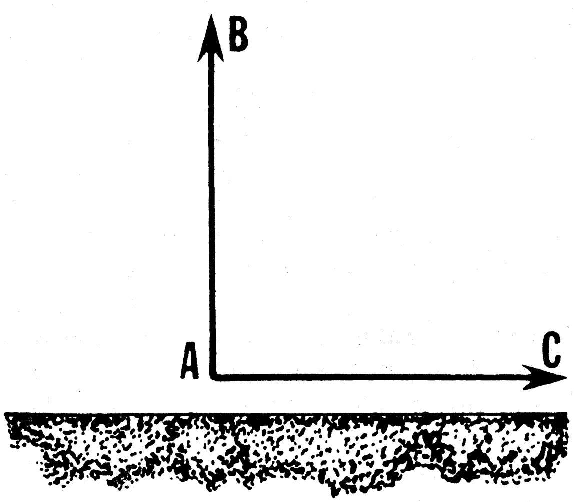


Figure 2–15. Horizontal and vertical components of electric force.

component of electric force and AC representing the horizontal component of electric force in direction and magnitude. For this to be true, there must be a potential difference between A and C. However, since the surface is a perfect conductor and has no resistance, there can be no difference of potential and likewise no lines of electric force. Therefore, AC cannot exist. The salt water of the ocean has high conductivity in this respect. Figure 2–16 shows a cross section of a wave front over the ocean with a vertical electric force being represented in direction and magnitude by the single arrow or vector AB. When a wave is transmitted over the earth's surface, with its low conductivity, there are losses into the semiconducting material which result in a horizontal component of electric force in the direction of wave travel, as shown by the two vectors in figure 2–17. The consideration becomes more

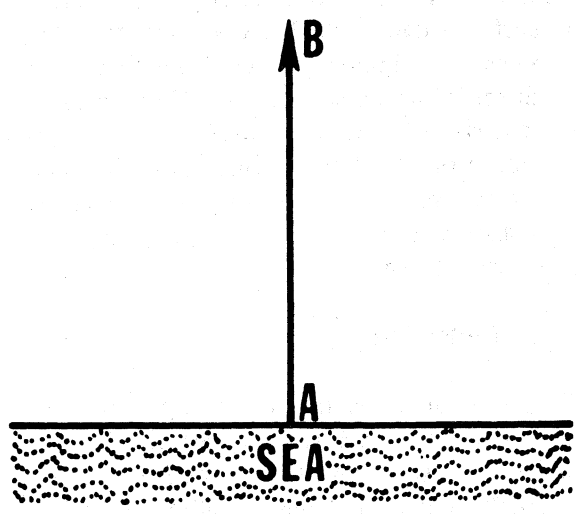


Figure 2–16. Vertical electric force in a wave traveling over a high-conductivity surface.

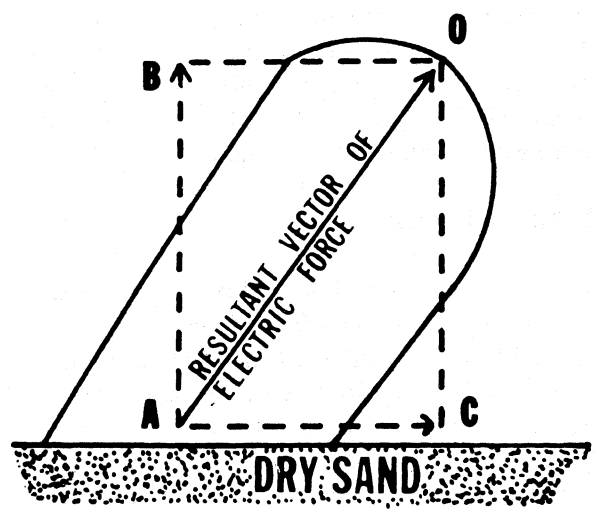


Figure 2–17. Elliptical electrical force in wave traveling over a low-conductivity surface.

complex because the vertical electrical force and the horizontal component are not usually in phase with one another, thus producing a rotating field of elliptical form, as illustrated in figure 2–17. The conductivity of the earth, or surface over which wave fronts pass, becomes very important when dealing with the different antennas used in DF operations, particularly the Adcock antenna. Although the values of conductivity and resistivity vary widely for soils of apparently similar types (they also vary with frequency), they are not appropriate to this manual.

2–17. Reflection.

When one observes himself in a mirror, the light beams or waves transmitted directly off the mirror's silver finish give the identical or "mirror" image, barring parallax or other optical distortions. Radio waves act in a similar manner to light waves, traveling at the same speed. Although light waves can be seen, radio waves must be detected by electronic equipment. Illustrations in this section will deal with both media. Figure 2–12 illustrates how radio waves are reflected off the ionosphere. Radio waves are reflected off the earth's surface, but are of little value unless the transmitting and receiving antennas are in close proximity of one another. The reflective and refractive components of light beams are illustrated in figure 2–18. The reflection of radio waves is illustrated in figure 2–19.

2–18. Refraction.

When the beam of a flashlight is directed at an angle on the smooth surface of water, some of the light will be reflected and the remaining portion will penetrate the water, as shown in figure 2–20. Refraction can also be observed by examining a glass of water into which a spoon is immersed. If viewed from an angle, the spoon appears broken or bent at the point where it enters the water because light waves travel at a slower speed through water than

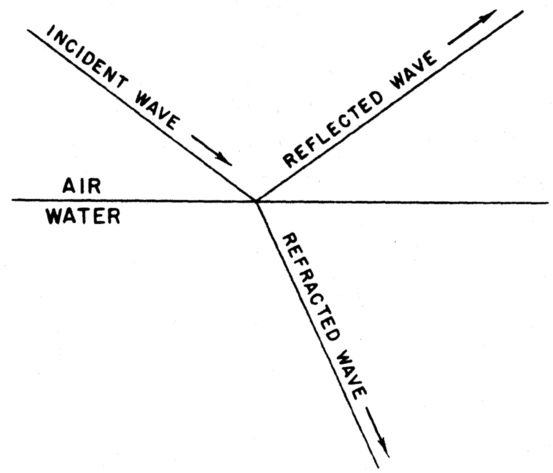


Figure 2–18. Reflection and refraction of a light beam.

through air causing a change in direction of travel of the refracted light. Figure 2–20 shows how this change in the direction of the light beam occurs. The parallel lines in this figure represent the wave front of a light beam incident to the surface of the water. Consider the wave front A–A1 (fig. 2–20), hitting the surface of the water. Since the speed of light is less in water than in air, point A will advance the distance d_1 in a given length of time, whereas point A1 will travel a greater distance (d_2) in the same length of time. As a result, the wave front will turn in a new direction. Note that refraction occurs only when the wave or beam of light approaches the new medium at an oblique angle. If the whole wave front arrives at the new medium at the same moment (perpendicularly), it is slowed uniformly and no bending occurs.

2–19. Diffraction.

If a beam of light in a dark room shines on the edge of an opaque screen, it will not form a perfectly outlined shadow because the light rays bend around the edge of the object, decreasing the area of total shadow. The diffraction or bending of a light wave around the edge of a solid object is slight. The lower

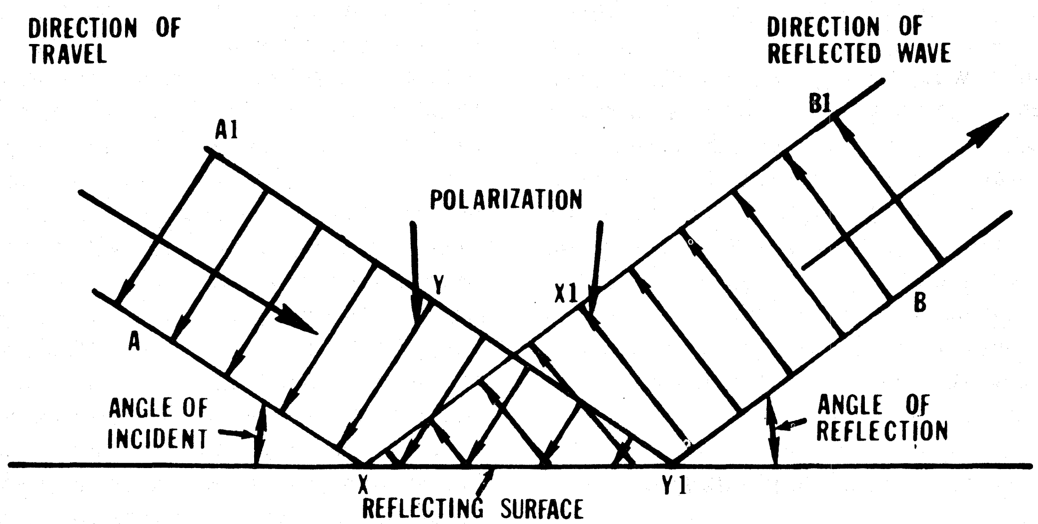


Figure 2–19. Reflection of a planar wave front.

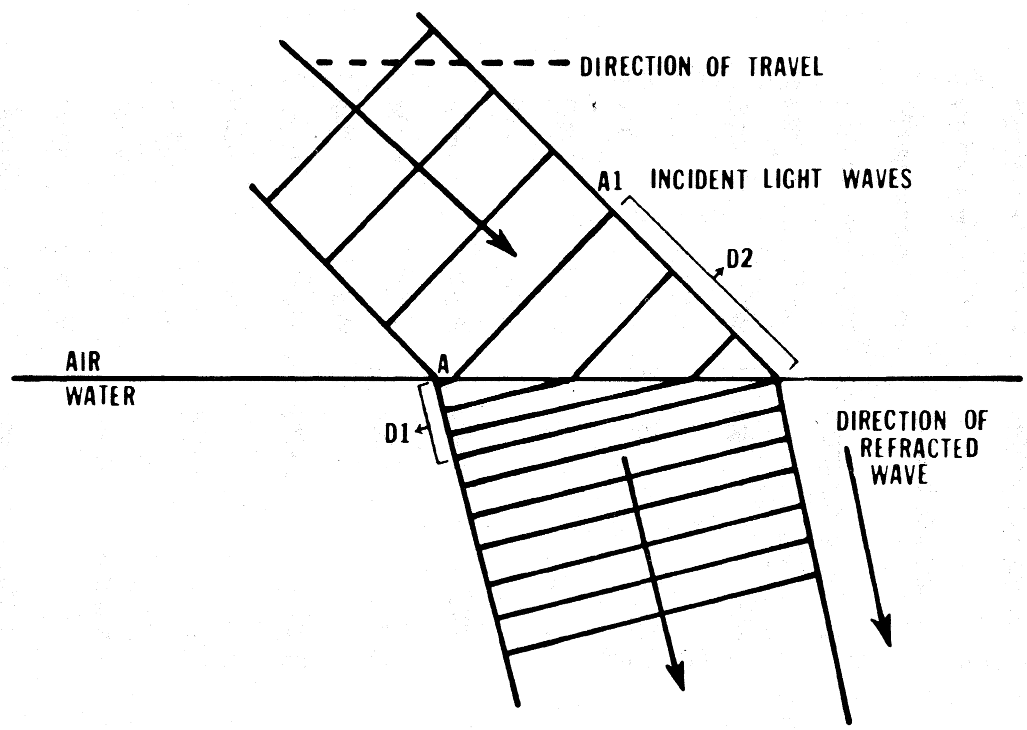


Figure 2–20. Bending of a wave front by refraction.

the wave frequency, or the longer the wavelength, the greater the bending of the wave. Therefore, radio waves are more readily diffracted than light waves, and sound waves more than radio waves. Figure 2–21 illustrates why radio waves of the proper frequency can be received on the far side of a hill or other natural obstruction, and why sound waves can be heard readily around the corner of a large building. Diffraction is an important consideration in the propagation of radio waves over long distances because the largest object to be contended with is the curvature of the earth, which prevents a direct passage of the waves from the transmitter to the receiver.

2–20. Skip Zones and Skip Distances.

In the foregoing discussion on propagation factors, the skip zones and skip distances have been illustrated, although not explained. Simply stated, the skip zone is that area in which the groundwave can no longer be detected (area AB, fig. 2–9) and the skywave has not yet returned to earth after being reflected or refracted off the ionosphere or troposphere. The wave front has "outrun" the groundwave portion, and the skywave portion has not returned to earth after reflecting off the ionosphere. The skip distance is that area where no skywave reception will normally be possible (area CD in fig. 2–9) since the wave has not returned to earth after its first or subsequent bounce off the reflecting layer. Depending upon the frequency and the transmitter power, multihop transmissions are routinely used for communications; there will be, however, skip distances between the points of the waves' return at each hop. Figure 2–22 illustrates multihop transmissions.

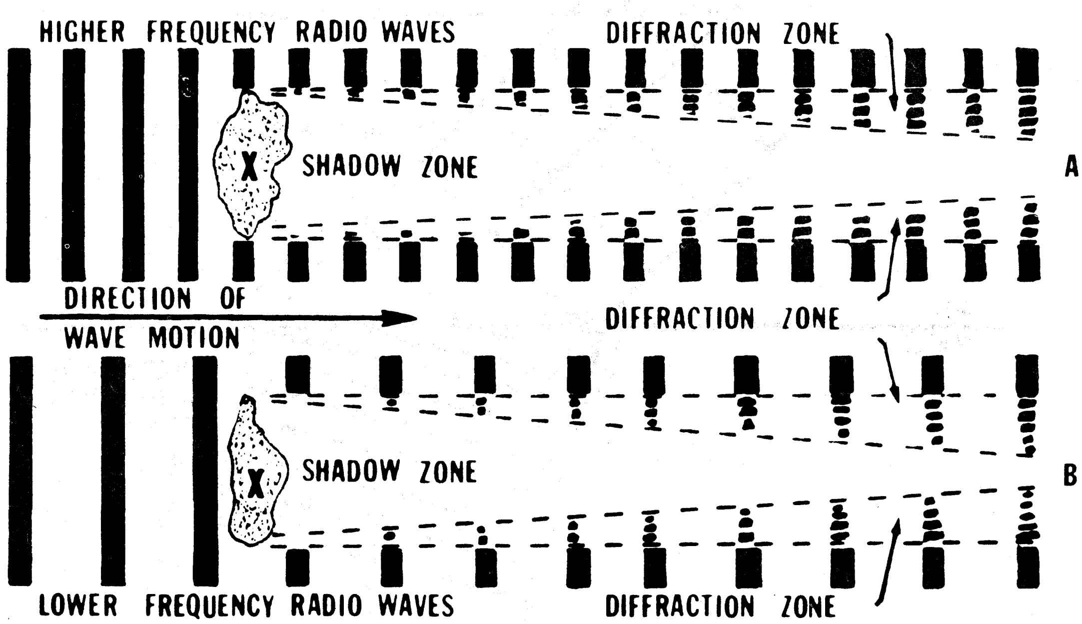


Figure 2–21. Diffraction of waves around a solid object.

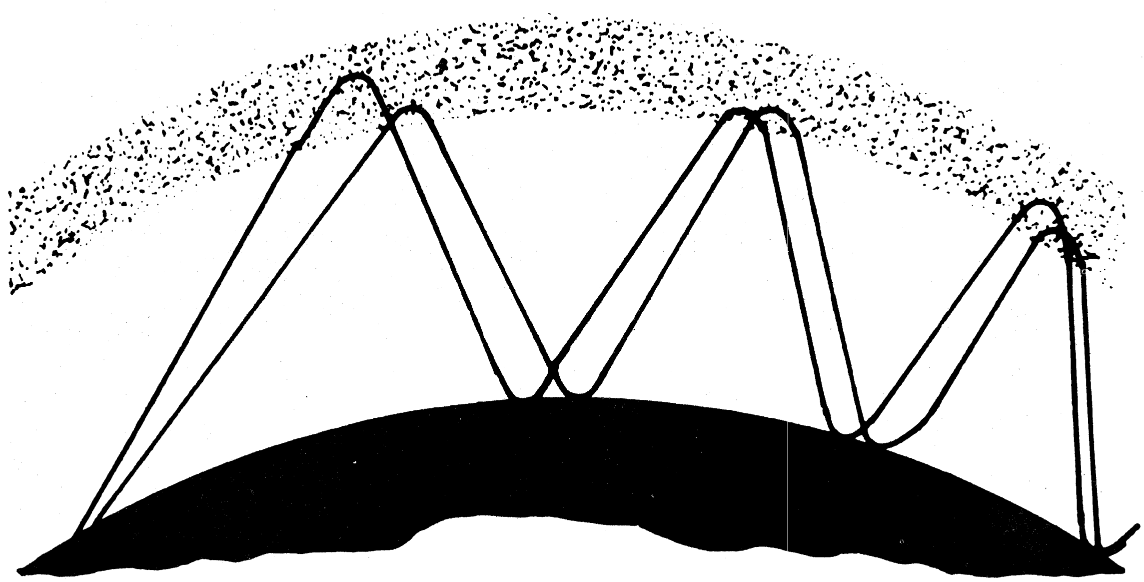


Figure 2–22. Multihop transmission.

Section IV

VHF AND UHF TRANSMISSIONS

2–21. VHF Transmissions.

The majority of all Frequency Modulated (FM) communications links operate within the frequency range of 30 to 300 MHz, (VHF band). Several FM radio sets are employed by US forces with speech security devices. This equipment provides secure communications in a wide variety of tactical situations. The planning range for this VHF equipment, with the transmitter and receiver located at ground level and no intervening hills, buildings, towers, or similar obstructions, is approximately 32 kilometers from a fixed location and 24 kilometers if moving. By increasing the height of the receiving antenna (as in an airborne platform) above the ground, it is readily apparent that the usable range of VHF signals for DF operations is greatly increased. This portion of DF application is covered more fully in section IV, chapter 4, of this manual.

2–22. Secondary DF Applications of VHF Transmissions.

Particularly in helicopters or other slow, low-flying aircraft, the "homing" use of VHF transmissions is important. When weather conditions deteriorate and visibility is marginal, the aircraft commander, copilot, or observer may use a homing antenna or homing adaptor. By tuning the receiver to a known friendly frequency in the VHF band, having that station key its transmitter for extended periods (20–30 seconds), and rotating the antenna for a null, the general direction of the transmitter can be determined. This method will be explained in paragraph **3–1**. By flying the aircraft in the direction indicated by the null, the VHF

signal becomes a ground navigational aid. Although this is DF homing instead of target locating, it is another useful application of the principles of DF.

2–23. UHF Transmissions.

Equipment is undergoing research and development, and in some cases field testing, for UHF DF applications. Since the principles and systems for UHF will be similar to those employed in VHF, they will not be discussed here.

CHAPTER 3

DF System Components and Characteristics

Section I
RADIO DF ANTENNAS

3–1. Polar Diagram of Antennas.

In the study of DF, it is convenient to have some method of illustrating the receiving sensitivity of an antenna system for various angles of arrival of an incoming wave. A method to illustrate this for both transmitting and receiving antennas is the polar plane diagram.

a. In figure 3–1, the plus mark at the zero point represents the directive antenna system of a receiver. To indicate the antenna sensitivity (response pattern) for signals arriving from different directions move a portable transmitter in a circle around the antenna, keeping the transmitter power output and distance from the receiving antenna constant. Measure the receiver input and compare with the transmitter output at known angles (0, 10, 20 degrees, etc.). If radial lines are drawn from the central point with each line corresponding to the azimuth for which the receiver input was measured, and if the lengths of these lines correspond to the receiver input voltages, the curve obtained

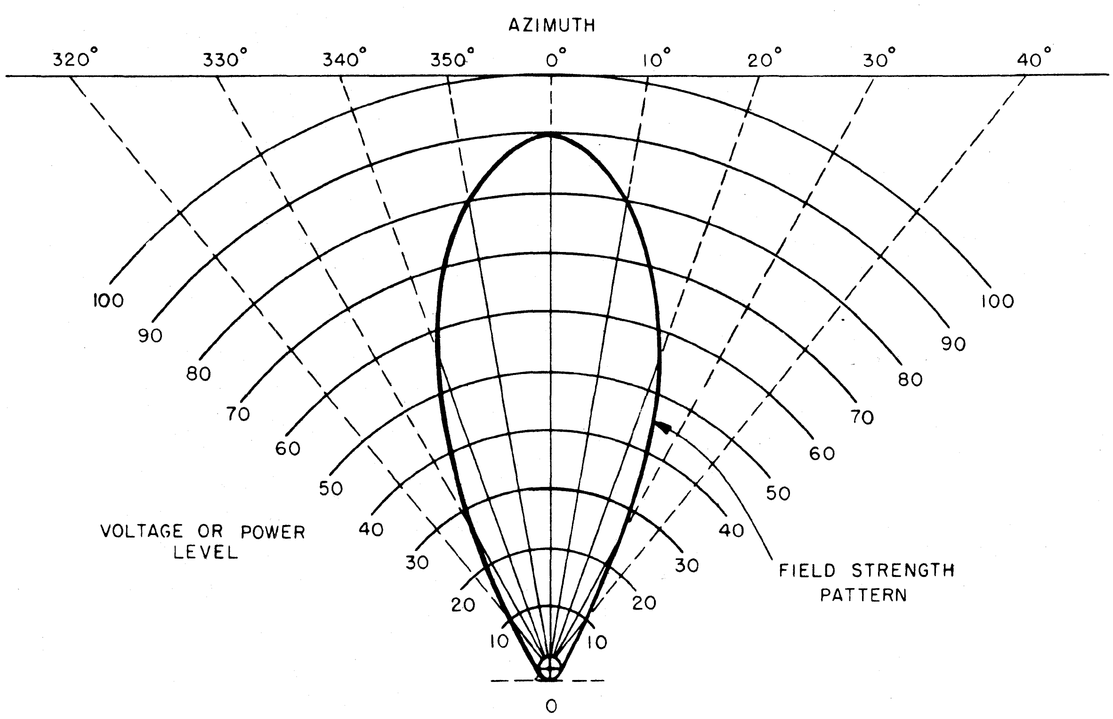


Figure 3–1. Polar diagram.

by joining the extremities of all these lines will give a clear picture of the directional properties of the antenna system. For example, in figure 3–1, the level of receiver input is 80 volts at 10 degrees, 69 volts at 15 degrees, 56 volts at 20 degrees, 27 volts at 30 degrees, etc.

b. When the polar diagram of a directional transmitting antenna is made, the process is reversed so that the receiver circles the antenna. In either case, the transmitter output and the receiver gain must be kept constant during the test so that the measured signal strength changes only because of directivity.

3–2. Loop Antennas.

Loop antennas are as old as radio itself. Heinrich Hertz used them in his original experiments with radio transmission and reception, and their directional properties were known long before there were enough radio transmitters to make direction finding worthwhile. A loop antenna consists of one or more turns of conductor, either self-supporting or wound on an insulated frame. The most commonly used styles are square (fig. 3–2) or circular (fig. 3–3) loops. The loop in figure 3–2 is illustrated as one turn of wire.

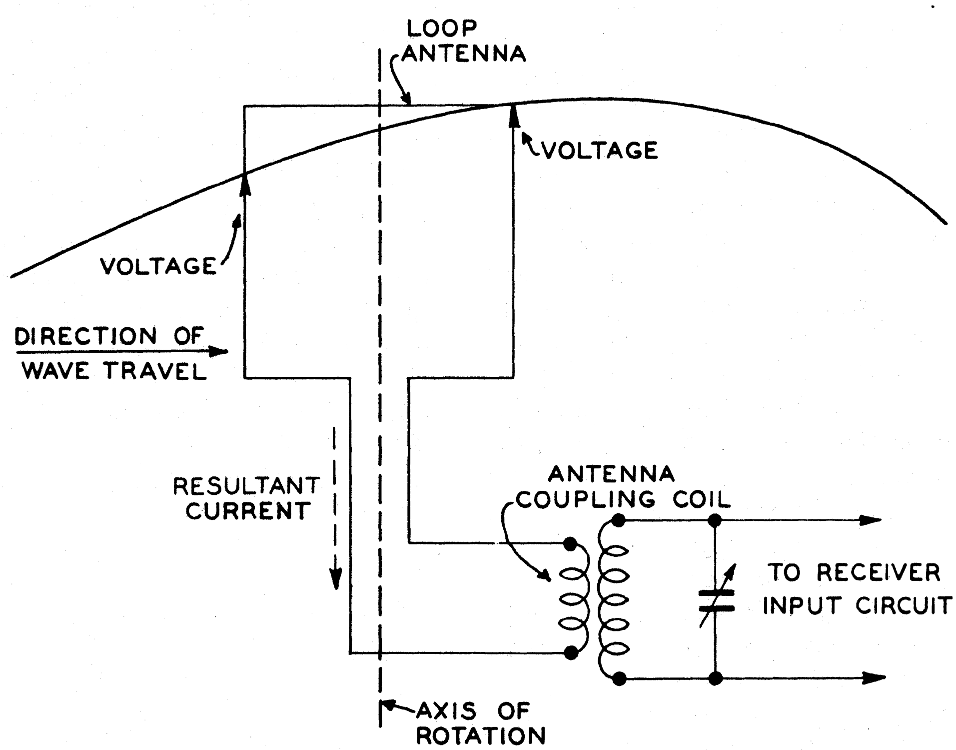


Figure 3–2. Simple loop antenna.

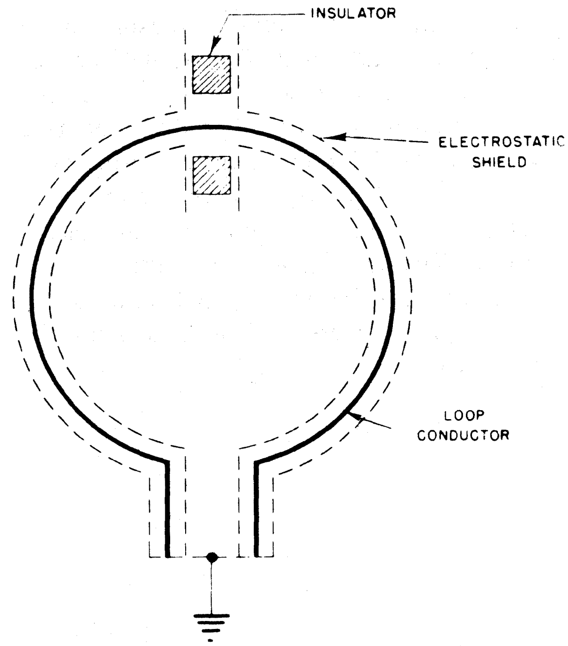


Figure 3–3. Circular loop antenna.

a. Maximum Reception. Consider the loop placed in the path of a vertically polarized wave with one side of the antenna closer to the transmitter than the other. With the plane of the loop parallel to the direction of wave travel the wave front reaches the vertical sides at slightly different times. Since wave polarization is spoken of in terms of the electric field, the magnetic component of a vertically polarized wave is horizontal (see fig. 2–2). This horizontal magnetic component induces voltages in both vertical arms of the loop but not in the horizontal arms since the wave travels parallel to them. The voltages induced in the vertical arms partly cancel each other across the antenna coupling coil because the amplitudes of the induced voltages differ at any given instant of time. The resultant voltage has a relative magnitude proportional to the field intensity of the wave.

b. Minimum Reception. If the loop is rotated about a central vertical axis until it is broadside to the oncoming wave (perpendicular to the direction of wave travel), the voltages induced in the vertical arms are equal and in phase, and will cancel across the antenna coupling coil to give minimum reception. This point of minimum response is called a null.

c. Pattern with Normal Polarization. When the incoming radio waves are vertically polarized, the condition under which a vertical loop would be used for direction finding, the loop antenna has a figure-eight response pattern. In figure 3–4, the loop appears in the 90–270 degree position; any signal received from either of these directions will induce maximum signal into the receiver. As the loop is turned away from the direction in which the wave is arriving (90–270 degrees), the received signal decreases, reaching a minimum when the loop is in either the 0 or 180 degree position. The line of direction (bearing, azimuth) to a transmitter can be determined by rotating the loop on its vertical axis until either a null or a maximum signal is produced. The transmitter direction will be broadside to the loop at the null or edgewise to the loop at the maximum. The appropriate direction will be indicated by an azimuth scale attached to the loop (fig. 3–5). It is customary to use the minimum rather than the maximum output of a loop when finding an azimuth since it permits a sharply defined indication and greater accuracy. The response pattern in figure 3–6 demonstrates the reason that this is so. In this instance, a maximum response of 100 microvolts (uv) is obtained with the loop edgewise to direction A (toward the transmitter). With the loop pointing toward B, a 10 degree rotation, there is only a 1.5 microvolt change in signal strength; this difference is not noticeable in the receiver input. But with the loop broadside to a transmitter at D, a null position, a similar 10

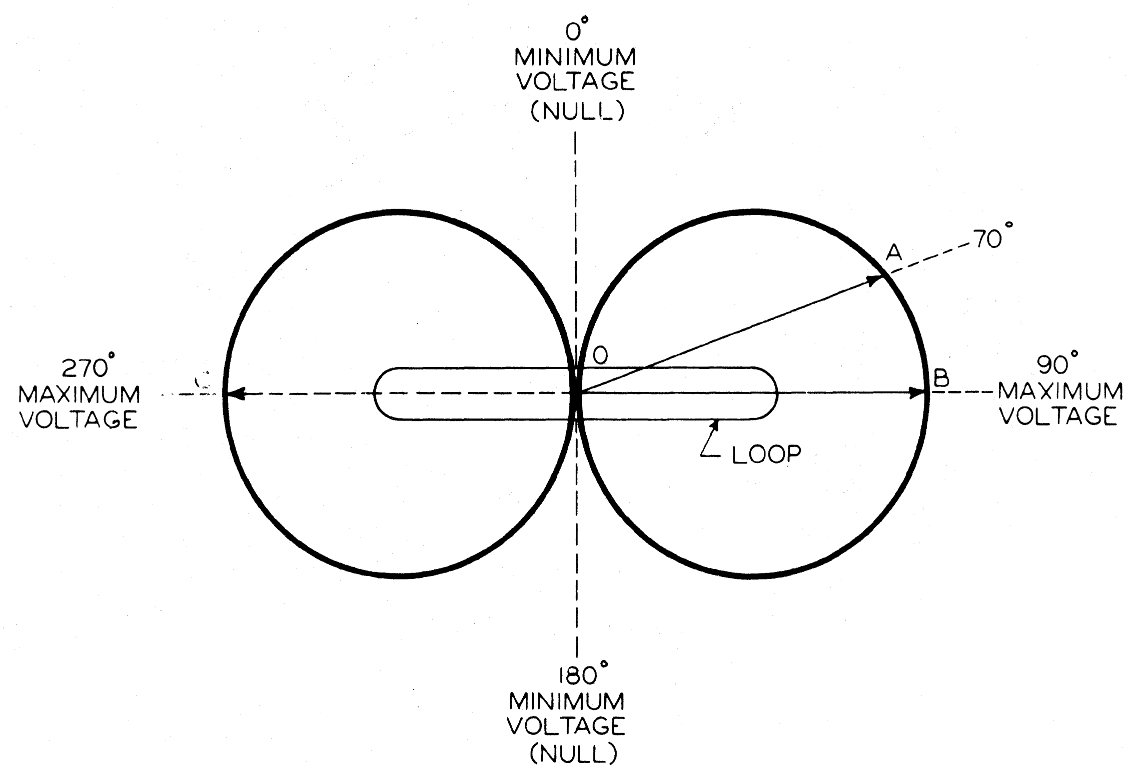


Figure 3–4. Loop antenna, figure-eight response pattern.

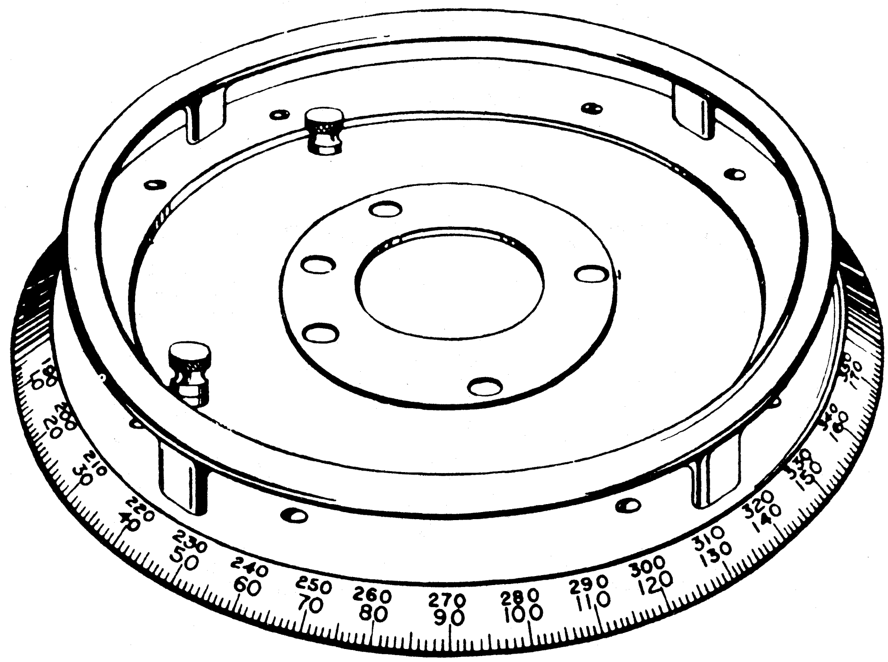
degree rotation causes a 17.4 microvolt change in signal intensity.

d. Pattern with Abnormal Polarization. Since vertical polarization is considered normal, any horizontally polarized wave is considered to be abnormally polarized for the simple loop direction finder. A horizontally polarized wave has no effect on vertical conductors, but it will induce voltage in horizontal conductors such as those at the top and bottom of a loop. For DF purposes, these horizontal conductors are considered to be ineffective and any induced current is considered inconsequential.

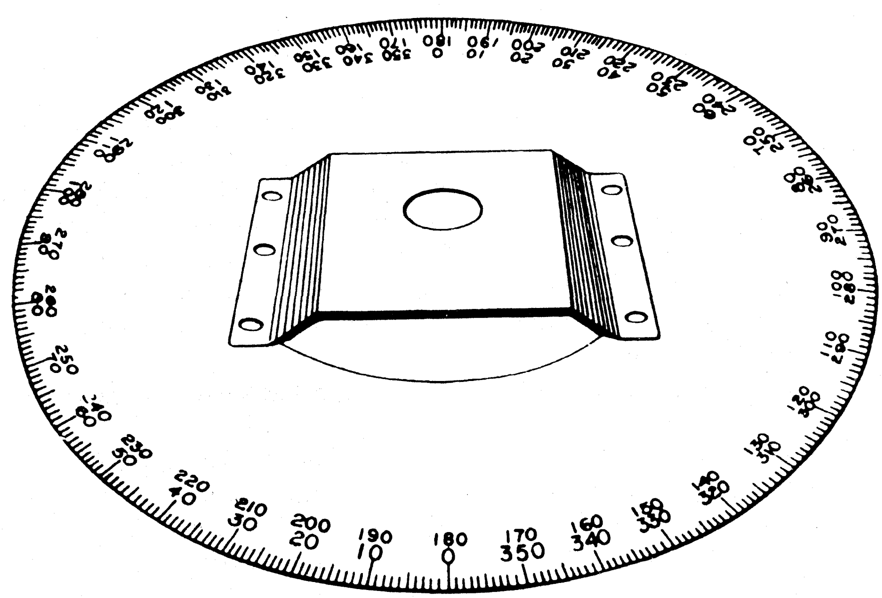
e. Ambiguity. Unless the general direction of the transmitter is known, a direction finder equipped with a simple loop antenna cannot determine whether a transmitter lies forward of or behind the direction finder. This 180 degree ambiguity is caused by the two null positions of the loop. Without a sense antenna or sensing circuit, there can be no indication which of the two directions is the correct azimuth.

3–3. Loop and Sense Antennas.

a. Purpose. The sense antenna is usually an omnidirectional vertical whip or monopole placed at the vertical axis of the loop. Both the circular response pattern of the sense antenna and the figure-eight pattern of the loop are symmetrical, but when properly combined the two antennas produce a lopsided or unidirectional pattern (the cardioid pattern or "valentine-shaped heart"



COUNTER CLOCKWISE SCALE



CLOCKWISE SCALE

Figure 3–5. Azimuth scales.

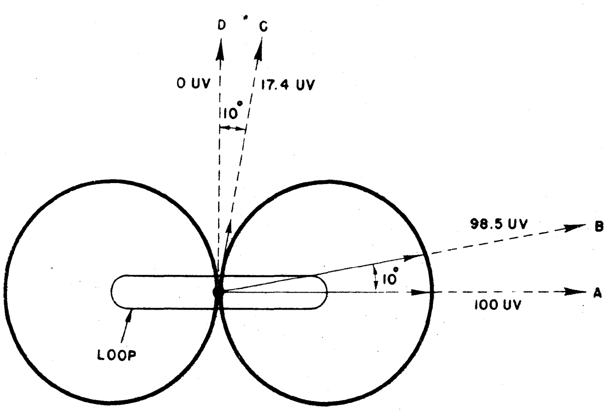


Figure 3–6. Change in loop position versus change in signal voltage.

in fig. 3–7). The large end of this pattern lies to the right of one null and to the left of the other null of the figure-eight pattern. By observing the relative position of the unidirectional pattern, the two nulls can be distinguished, thus resolving the 180 degree ambiguity of the simple loop. One null is arbitrarily designated as the front or direct null, while the other is called the back or reciprocal null.

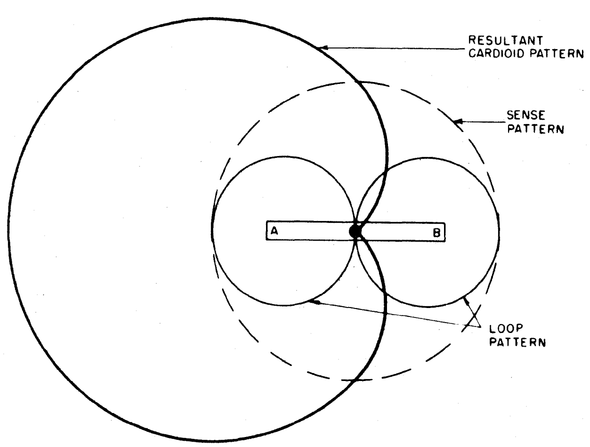


Figure 3–7. Cardioid response pattern obtained by combination of circular and figure-eight voltages.

b. Application. After the loop has been turned to a null, the direction may either be read from an azimuth scale or observed directly. The sense antenna is then placed in operation to change the response pattern from a figure eight to undirectional. The null vanishes due to this change. Upon turning the loop 90 degrees to either side from the former null position, the response is found to be greater on one side than on the other. Which side is greater depends on whether the loop originally had the direct null facing toward or away from the transmitter. As a rule, if the response increases as the loop is turned clockwise, increasing the azimuth scale reading, or if the response decreases as the azimuth reading decreases, the direct null was toward the transmitter. If the response changes in the opposite direction, the reciprocal null was toward the transmitter. This relationship is not always used. It can be reversed by transposing connections in the antenna circuit to reverse the relative polarity of loop and sense antennas, or by a 180 degree shift in the position of the azimuth scale or pointer relative to the loop. There are cases in which such a reversal has been made intentionally.

3–4. Cardioid Theory.

When the voltages from the loop and sense antennas are combined with the proper relative phase and amplitude, the resulting pattern is a heart-shaped curve known as a cardioid. A typical case is illustrated in figures 3–8 and 3–9.

a. A radio wave traveling past the loop, as indicated in capital A, figure 3–8, strikes leg No. 1 a short time before it strikes leg No. 2.

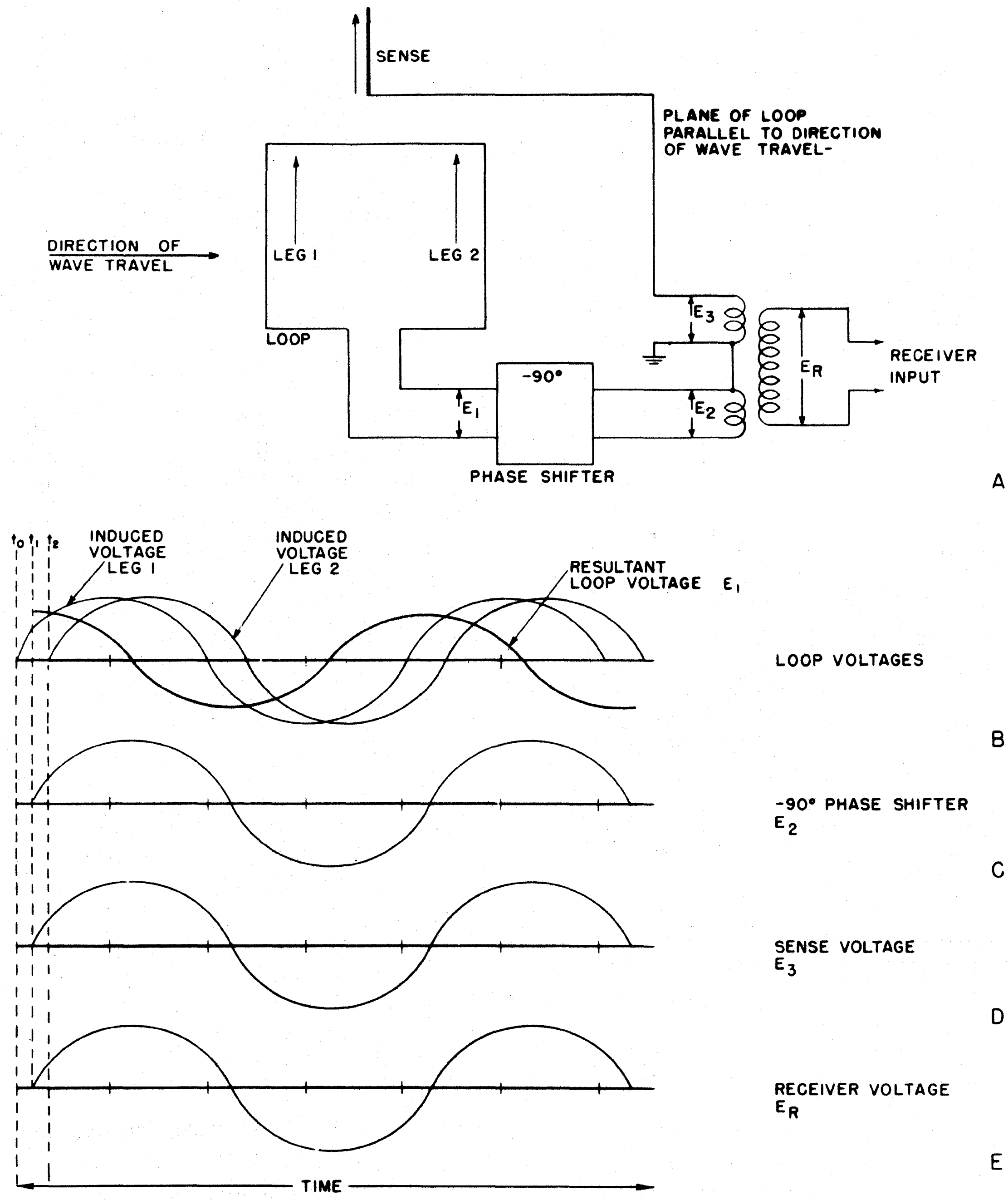


Figure 3–8. Loop and sense antenna system, relationship of voltages.

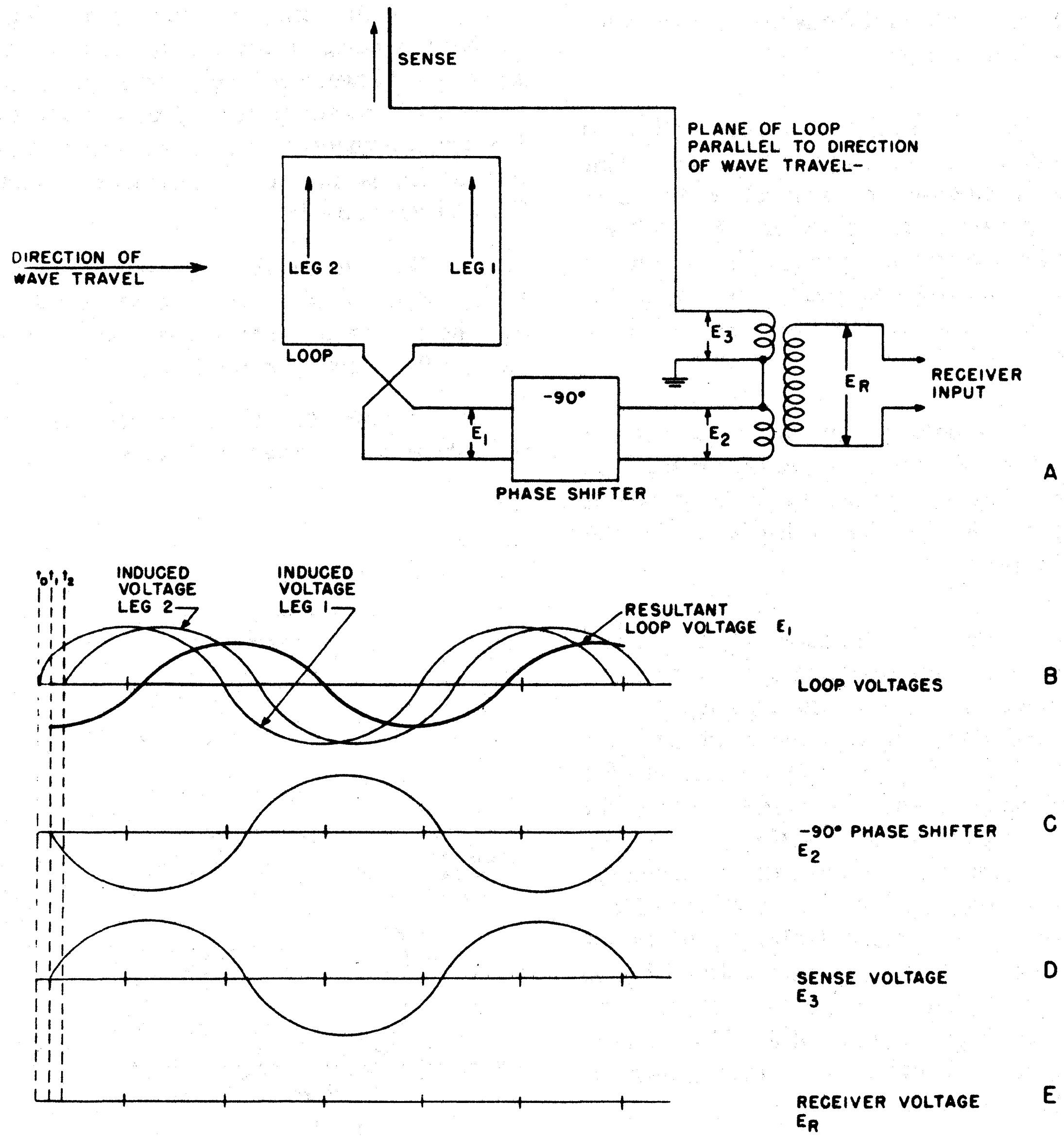


Figure 3–9. Relationship of voltages in loop and sense antenna systems when the loop has been rotated 180 degrees from the position shown in figure 3–8.

b. The voltages induced in the two vertical legs are connected in series opposition, so that the net output of the loop depends on their potential difference.

c. As shown in Capital B, figure 3–8, the voltage in leg No. 1 is starting to rise at time zero (t_o); the voltage induced in leg No. 2 starts to rise a short time later (t_2). However, where the output of the loop is concerned, the voltage induced in leg No. 2 is out of phase and begins to subtract from the voltage in leg No. 1 at this time (t_1).

d. The resultant voltage (E_1) is developed across the output of the loop. This voltage is directly proportional to the time delay (phase shift) between the voltages induced in the legs of the loop. The greater the separation between t_o and t_2 in Capital B, figure 3–8, the greater the resultant loop voltage.

e. It is apparent in Capital B that the resultant voltage leads the voltage induced in leg No. 1 by approximately 90 degrees and lags the voltage induced in leg No. 2 by the same amount.

f. Voltage E_3 induced in the vertical sense antenna is intermediate in phase between the voltages induced in the two legs of the loops, and therefore lags the resultant loop voltage E_1 by 90 degrees. To compensate for this phase difference (to have either an in-phase or out-of-phase relation between the resultant loop voltage E_1 and the sense voltage E_3), it is necessary to advance or retard the phase of the loop voltage by 90 degrees with a phase shifter. Retarded loop voltage E_2 is shown in Capital C, figure 3–8. If the loop voltage had been advanced, it would be shifted 180 degrees in phase from that shown in Capital C.

g. Notice that the retarded loop voltage E_2 and the sense voltage E_3, beginning at the same instant (t_1), are in phase. These two voltages add in the input transformer; the receiver voltage E_R is maximum (Capital E, fig. 3–8).

h. If the antenna is rotated on its vertical axis through 180 degrees, the electromagnetic wave strikes leg No. 2 before it strikes leg No. 1 (fig. 3–9).

i. The voltages across both legs are induced in the same manner, producing a resultant voltage again proportional to the separation between the legs. However, because of the loop rotation, the voltages of the two legs are interchanged and the resultant output voltage E_1 is shifted 180 degrees in phase (Capital B, fig. 3–9).

j. The retarded loop voltage E_2 is therefore out of phase with the sense voltage, and the minimum signal E_R is applied to the receiver (Capitals C, D, and E, fig. 3–9).

k. Assume that the transmitter azimuth is 0 degrees as shown in figure 3–10. At

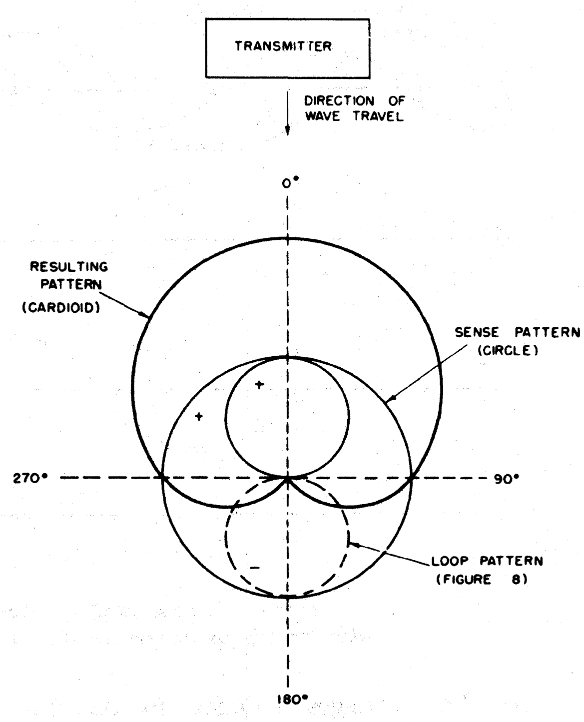


Figure 3–10. Cardioid response pattern.

intermediate points between the maximum and minimum positions of the loop, the following conditions exist:

(1) When the loop is rotated from 0 to 90 degrees, the loop voltage gradually decreases (the distance between the loop legs along the direction of wave travel becomes less). The sense voltage is constant and in phase with the loop voltage. The resultant receiver voltage is decreasing.

(2) When the loop is rotated from 90 to 180 degrees, the loop voltage gradually increases (the distance between the loop legs along the direction of wave travel becomes greater). The sense voltage is constant and 180 degrees out of phase with the loop voltage. The resultant receiver voltage decreases because of the out-of-phase condition.

(3) When the loop is rotated from 180 to 270 degrees, the loop voltage gradually decreases. The sense voltage is constant and 180 degrees out of phase with the loop voltage while the resultant receiver voltage increases.

(4) When the loop is rotated from 270 to 360 degrees, the loop voltage increases. The sense voltage is constant and in phase with the loop voltage while the resultant receiver voltage increases.

l. In practice, sense circuits are seldom adjusted to the ideal condition just described, and the resulting unidirectional pattern is not a perfect cardioid. If the sense voltage is very small, the resultant pattern is a slight lopsided figure eight. Increasing the sense voltage then makes the figure eight more and more lopsided, as shown in figures 3–11 and 3–12, until the sense voltage equals the maximum loop voltage. One lobe then disappears completely, making the pattern a perfect cardioid (fig. 3–13). Further increases of sense voltage increase the maximum and minimum resultant pattern (fig. 3–14), making it more and more like a circle. Either too little or too much sense voltage makes sense determination difficult, while any of the four patterns just mentioned would be acceptable. The

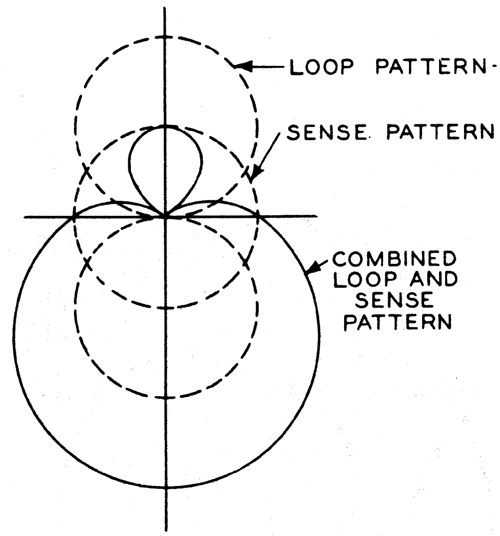


Figure 3–11. Response pattern, low sense voltage, and correct phase position.

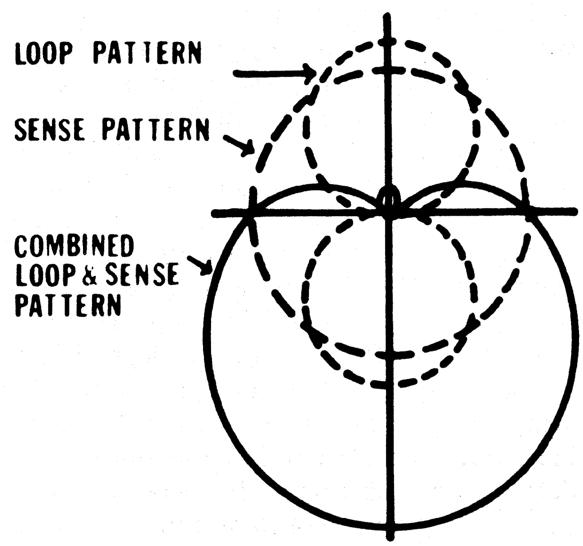


Figure 3–12. Response pattern, low sense voltage, and correct phase relation.

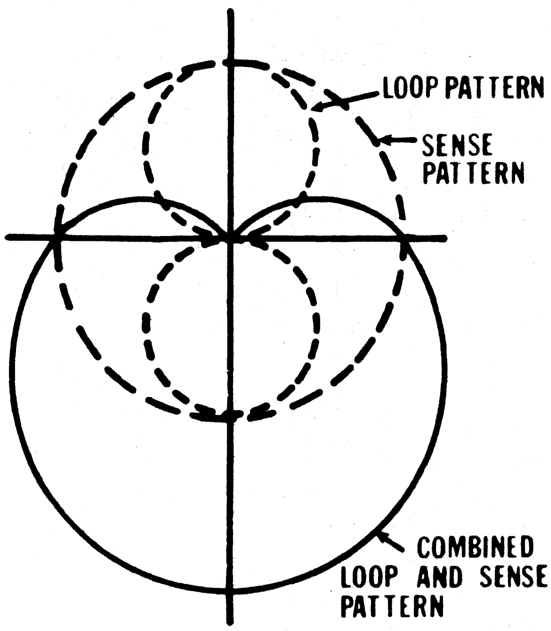


Figure 3–13. Response pattern, proper ratio of sense, and figure-eight voltage with correct phase relation.

lopsidedness of the resultant pattern is readily distinguishable as long as the sense voltage is within ± 50 percent of the maximum loop voltage. If the sense voltage is out of phase with the loop voltage, the resultant pattern becomes nearly circular, and the amplitude relation must be kept closer to the ideal for satisfactory operation. Figure 3–15 shows a case in which both amplitude and phase relation are far from the ideal. Here the sense voltage has about half the amplitude shown in figure 3–11, and is 40 – 50 degrees out of phase with the loop voltage. The lopsidedness of the resulting pattern could be detected by comparing its two maximums on a visual indicator. The difference is too small to be detected by listening. If necessary (for example, if part of the sense antenna is lost), such a pattern can be used by observing which way the null shifts when the sense switch is operated; both nulls shift toward the small end of the lopsided figure-eight pattern.

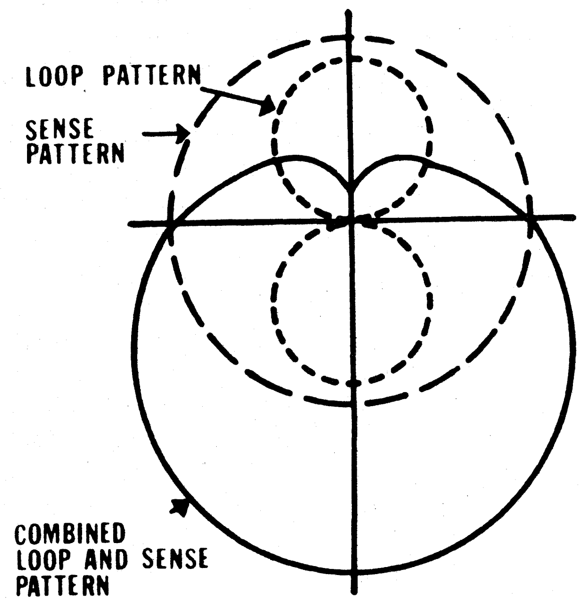


Figure 3–14. Response pattern, high sense voltage, and proper phase relation.

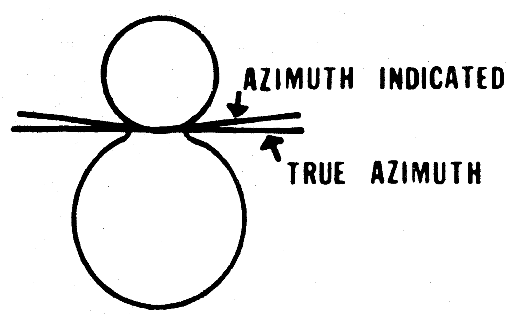


Figure 3–15. Response pattern, low sense voltage, and incorrect phase relation.

3–5. Loop Errors.

Several different factors can lead to undesired effects and incorrect azimuths. Some are peculiar to loops; others can affect any type of directional antenna. Errors arising from causes entirely outside the direction finder will not be discussed in detail here (see sec. III, chap. 5).

a. Antenna Effect. Antenna effect is the error in a loop antenna due to voltage loop imbalance.

(1) *Description.* When combined with the loop voltage, even a weak signal from the sense antenna may cause noticeable distortion of the figure-eight response pattern. If in phase or 180 degrees out of phase with the loop voltage, the sense-antenna voltage tends to make the figure eight lopsided, shifting the two nulls in opposite directions (fig. 3–11) so that they are no longer 180 degrees apart. If 90 degrees out of phase, the sense-antenna voltage tends to fill in the nulls, changing them to rounded minimums. At intermediate phase angles, both rounding and shifting of the nulls occur simultaneously (fig. 3–15). Usually the sense-antenna circuit is designed carefully to prevent any undesired addition to the loop voltage from that source, even though the same antenna effect is still applied to any pattern distortion caused by voltage from the sense antenna.

(2) *Causes.* Antenna effect may occur due to stray pick up. A small amount of signal may be picked up directly by an inadequately shielded receiver, or some circuit not intended as an antenna, e.g., power or telephone wires may pick up a signal and pass it along to the receiver. Probably the most important cause of antenna effect lies in the loop itself. Even when the loop is turned to a null position where the net loop voltage is zero, a relatively strong voltage is induced in each leg, just as in any vertical antenna of the same height. If the loop and associated circuits are properly balanced, this voltage has no effect on the receiver, while a slight imbalance may combine part of it with the loop voltage in the receiver, producing antenna effect.

(3) *Balance adjustment.* One of the simplest types of imbalance is inequality between the capacitances from each side of the loop to the ground. Such an imbalance can be corrected, as illustrated in Capital A, figure 3–16, by adding a capacitor to each side, making one of them variable so that it can be adjusted for balance. Similar results can be attained with a differential capacitor (Capital B, fig. 3–16). Capacitive balance adjustment can be used even if the imbalance is inductive (unequal inductance in the two sides of the loop), but then a different adjustment is required for each signal frequency, since inductive and capacitive reactances vary in opposing fashion as the frequency changes. A third arrangement, illustrated in Capital C, figure 3–16, uses a differential capacitor to introduce an impulse from the sense antenna. The capacitor is adjusted to make the injected voltage equal and opposite to that entering accidentally. Balancing or neutralizing arrangements are sometimes called null-clearing devices because they are highly effective in eliminating the component of antenna effect which tends to fill in the figure-eight nulls. This component (90 degrees out of phase with loop voltage) is usually the most important. Antenna-effect voltage in the loop is initially 90 degrees out of phase with the desired loop voltage. Loop imbalance couples it into the circuit with little or no phase shift; therefore, the desired and undesired voltages follow the same path and undergo the same phase shifts, retaining their initial relation.

(4) *Shielding and grounding.* Antenna effect originating in the loop itself can be reduced greatly by using an electrostatic shield, as shown in figure 3–3. Similar results can be obtained by grounding the electrical center of the loop. This method is most effective when the loop has an even number of turns so that the center and the

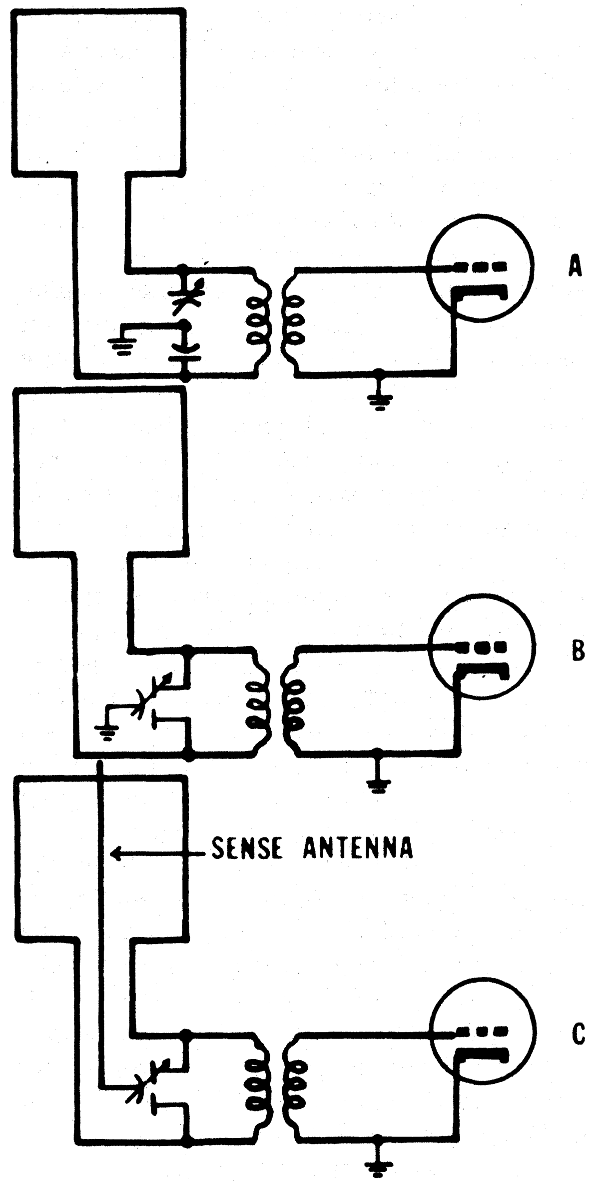


Figure 3–16. Method of balancing antenna effect.

terminals are close together and the ground connection is short. Despite this, it is still quite as effective as a shield. When an input transformer is used in the receiver, grounding the electrical center of the primary coil will reduce antenna effect. However, the electrical center is more difficult to locate accurately in the coil than it is in the loop. At frequencies far below the natural resonance of the loop or primary coil, grounding and the centertap location need not be extremely accurate. At nearer the natural resonance of the coil frequencies, the tapped coil serves chiefly as an inductive balancing device in a manner similar to the split-stator capacitor in Capital B, figure 3–16. Since its adjustment is fixed by the manufacturer, the center tap must be placed very accurately, and may have to be some distance from the mechanical center of the winding.

(5) *Operating techniques.* Even though technological developments have reduced antenna effect so that it is scarcely noticeable, fairly accurate readings can be obtained from older direction finders in which antenna effect is unpleasantly large.

(*a*) In cases where the nulls are filled in, the bottom of the resulting minimum cannot be located directly with any great precision, even though the minimum level is definite. By turning the loop back and forth, the operator can locate two points on either side of the minimum where the response rises above the minimum level by the same small amount. The null position is midway between these two points, with a probability error of 10 to 20 percent of their separation, depending on the skill of the operator.

(*b*) If the two nulls are displaced from their normal 180 degree separation, each null will be in error by an equal but opposite amount (fig. 3–15), called the reciprocal error. This error can be eliminated by averaging the direct azimuths determined from observation of the two nulls. The corresponding direct azimuth is computed from the azimuth at the reciprocal null by adding or subtracting 180 degrees if it is not shown by a separate set of numbers on the azimuth scale.

b. Weak Signal.

(1) If the signal is weak or the

background noise is high, several azimuths should be taken when the signal appears strongest. These readings can be averaged to give a reasonably accurate azimuth.

(2) If it is impossible to use the null points, an approximate azimuth can be found by using the maximum points. Direct azimuth, when turned to maximum, is indicated by a signal strength increase when the sense switch is turned on. When the maximum point is used to determine the azimuth, the actual value is 90 degrees less (or more) than the reading of the azimuth indicator.

(3) Often when the noise level is high, the null can be located by averaging the azimuths (up to 90 degrees apart) at which the signal rises above or falls below the noise. Even with low noise levels it is sometimes easiest to locate the null by splitting the arc within which the signal is exceeded by the noise.

c. Polarization Effects. As explained in paragraph **3–4***c*, the response pattern of a loop antenna varies with the polarization of the radio waves received. Abnormal polarization may cause DF errors by rotating the whole pattern or by filling in the nulls, making them difficult to locate. These effects, already observed under several different conditions are:

(1) *Night effect.* When receiving only groundwave signals, a loop is free from polarization effect, both because it has a null in the horizontal direction for horizontally polarized waves, and because any transmitting antenna located near the ground also has a null (or a very small minimum) for horizontally polarized radiation in the horizontal direction. This justifies the assumption that groundwaves are vertically polarized. Skywaves, on the other hand, may have any kind of polarization since they come down at some angle above the horizontal. The loop then responds to the horizontally polarized component as well as to the vertically polarized component of the wave. At the low and medium frequencies used when radio first became popular, the ionosphere was a much better reflector at night than in the daytime, and skywave reception was possible at night over distances far beyond the groundwave range. Thus polarization error, due to abnormal polarization in the skywave, was first observed at nightfall, and has been called a night effect ever since.

(2) *Fading and swinging.* When both groundwaves and skywaves are received simultaneously with nearly equal intensity, interference results. As the height of the ionosphere fluctuates, the skywaves change phase with respect to the groundwaves, sometimes adding to them, sometimes opposing them. The resultant intensity of the vertically polarized component varies widely, being sometimes much greater and sometimes much less than the horizontally polarized component. As a result, the polarization error varies, and the azimuth indication swings back and forth, making it very difficult to obtain an accurate reading. The amount of swing depends on the relative intensities of the skywaves and groundwaves, reading a maximum of ± 90 degrees if their vertically polarized components cancel each other in the loop.

(3) *Airplane effect.* Polarization error also occurs in direction finding on an airborne transmitter, particularly one using a trailing wire antenna. When the aircraft flies radially to or from the direction finder, vertically polarized radiation is received, and normal results are obtained by DF. When the aircraft follows a tangential course, the received signal has more horizontal than vertical polarization, and the target signal suffers from a polarization error which shifts the indicated azimuth toward the lower end of the trailing wire. Usually this end is to the rear of the aircraft. For courses intermediate between radial and tangential, the ratio of horizontal to vertical polarization is smaller, and so is the error.

d. Winding Arrangement. In an unshielded loop antenna, the arrangement of

turns may have an appreciable effect on the directivity pattern. The ideal figure-eight pattern applies exactly to a single turn loop, while more complicated patterns may be obtained when a number of turns are used, unless the turn arrangement is carefully chosen.

(1) *Symmetrical pancake winding.* If the loop turns are wound so that each turn is symmetrical (Capital A, fig. 3–17), the directivity of the loop will be the same as the directivity of any one of the turns. The vertical transition between turns is concentrated in one location with the upgoing and downcoming wires close together. As a result, the voltages induced in these opposing wires are equal. Complete cancellation takes place, and only those voltages induced in the main portions of the loop affect the receiver.

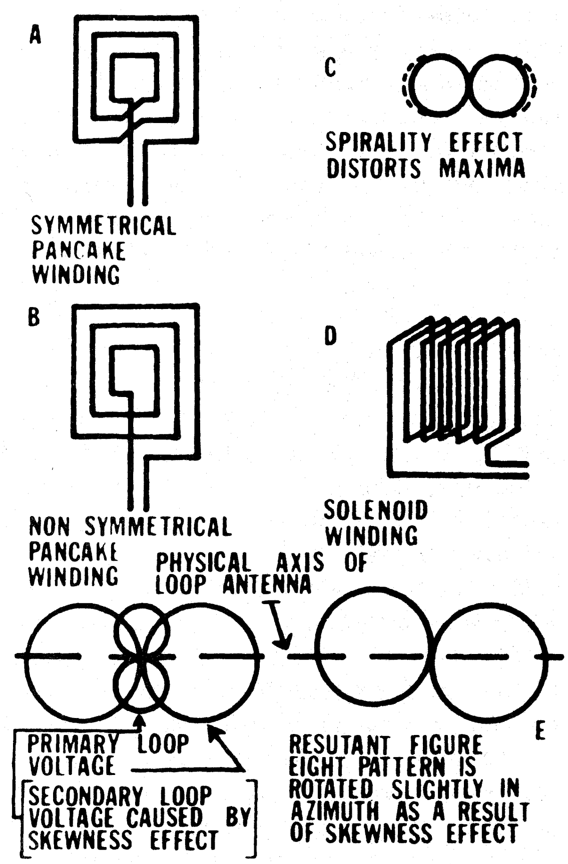


Figure 3–17. Effect of winding arrangement.

(2) *Spiral pancake winding.* If the turns are wound spirally (Capital B, fig. 3–17) so that the upgoing side of each turn is longer or shorter than its downcoming side, the pancake loop becomes nonsymmetrical. The inductance and capacitance of the winding are unevenly distributed between the two sides, and this imbalance leads to an antenna effect. The loop circuit can be balanced as shown in figure 3–16, but the relative influence of inductive and capacitive imbalance changes with frequency, so that the compensating capacitor must be readjusted whenever the receiver is tuned to a different frequency. Theoretically, the difference in pick up of a symmetrical and nonsymmetrical pancake, due to the spirality of the latter, is equivalent to the pick up of a small pair of coplanar spaced loops. This tends to make the response pattern slightly sharper at its maximums. (See Capital C, fig. 3–17.) However, this spiral effect is imperceptible in any loop small enough to need more than one turn.

(3) *Skewness.* When a solenoid winding is used for a loop antenna, its form is usually helical, similar to that shown in Capital D, figure 3–17. As the winding progresses, one side of each turn is further advanced than the other by half the spacing between the turns. Thus, the turns are skewed slightly, and their nulls are turned a fraction of a degree from the axis of the helix. A skewed winding is equivalent to two windings without skew (i.e., a primary winding coaxial with the frame, and a smaller secondary winding at right angles with its horizontal part parallel to the axis of the actual helical winding). The secondary loop, figure-eight response pattern (Capital E, fig. 3–17) adds either in-phase or out-of-phase to the primary figure-eight loop voltage. The resultant pattern is also a figure eight, but it has its orientation rotated slightly (much less than that illustrated) from the primary figure-eight pattern.

(4) *Width effect.* The capacitance between adjacent turns of a solenoid winding produces an effect similar, but with opposite polarity, to that of skewness. As shown in figure 3–18, these capacitances form horizontal members of a secondary loop which is oriented 90 degrees away from the primary loop. The effect of this secondary loop increases with increasing frequency, and becomes large enough to cancel the skewness effect at a frequency slightly below that at which resonance occurs within each turn. If there is leakage between turns due to poor

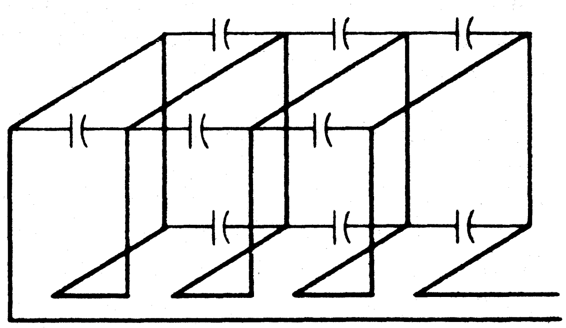


Figure 3–18. Distributed capacities in solenoidal loop.

insulation, the capacitors shown in figure 3–18 may be considered shunted by resistance. This shifts the phase of the secondary loop voltage so that it fills in the nulls of the primary figure-eight pattern rather than rotating the pattern. The result resembles antenna effect. However, because the polarity of the two lobes of the secondary figure eight is opposite, while the circular pattern of actual antenna effect has the same polarity all around, width effect and antenna effect tend to add at one null and cancel at the other so that one becomes slightly more rounded than the other.

(5) *Combination windings.* The peculiarities explained in (2), (3), and (4) above are all attributable to dissymmetry in the loop windings, and can be reduced or eliminated by making the windings more symmetrical. One symmetrical case is shown in Capital A, figure 3–17. Nearly the same results can be obtained with spiral windings if an even number of pie windings (a method of constructing coils from a number of individual washer-shaped coils called pies) are used, provided that the pies are wound in opposite directions; i.e., spiraling outward and inward alternately. This arrangement keeps the loop balanced and neutralizes the spiraling effect, but still leaves a little width effect. Both skewness and width effect in a solenoid winding can be neutralized by using an even number of layers, one layer being wound from left to right and the next from right to left. Similar results may be obtained with universal windings in which the axial progression of turns is reversed periodically by a cam in the winding machine. Balance still requires an even number of pies which again introduces width effect, which will be insignificant if the number of turns per pie is more than the number of pies. When many turns are used, shielding the loop is often the simplest and most effective solution, since it practically eliminates skewness and width effect. It also reduces antenna effect so that balance becomes less important.

3–6. Loop Construction.

a. Balance. The most important factor in the physical construction of a loop is its symmetry. When the loop is symmetrical, electrical balance follows automatically. If the balance is good enough, antenna effect will be insignificant. Any conducting material near the loop, such as the top of the radio receiver case, should be placed symmetrically, otherwise the loop might be balanced at some positions but unbalanced at others. In the case of a square loop, it is preferable to place a corner rather than a side at the bottom. This arrangement keeps the body of the loop farther away from the ground so that any irregularities (including metal items worn by the operator) are less likely to affect the loop balance.

b. Electrostatic Shield. Multiturn loops are often encased in an electrostatic shield. This is a metal case, or a film of metal on a case of some other material, which surrounds the loop winding almost completely (fig. 3–3). There is a gap in the top of the metal, and the opposite sides of the gap are insulated from each other to prevent the shield from forming a closed (short-circuited) loop. The shield is grounded near the loop terminals as far as possible from the insulated gap. As a vertical antenna, therefore, the shield is short-circuited. Consider the voltages induced by a passing radio wave made up of two components, one corresponding to the desired loop voltage, the other to the antenna effect. Although the former can produce very little current in the shield because of the insulated gap, it is fully effective in the loop having conductors crossing that gap. The latter causes a flow of current over the shield to the ground. Since the ground connection is short circuit, this current produces a counterelectromotive force in the shield equal to the original induced voltage. It induces a voltage in each loop conductor which nearly cancels the original antenna effect voltage induced there by the radio wave. The reduction ratio is substantially the same as the Q (reactance/resistance ratio), which the shield would have if connected as a loop. Since the Q is seldom less than 10, the residual antenna effect is seldom more than one-tenth the antenna effect with no shield. In addition to reducing antenna effect directly, the shield helps indirectly. Unless an external object is very close to the gap in the shield, it cannot affect the capacitance from loop to ground, and thus cannot change the capacitive balance of the loop. However, the shield affords no protection against inductive imbalance which might be caused by a scrap of metal placed too close to one side of the loop. The shield also eliminates the precipitation static caused by electrically charged rain drops striking the antenna and provides mechanical protection for the loop.

c. Loop Size. Except in some special VHF loops, which resemble groups of dipoles more than they do ordinary loops, the largest dimension of a loop antenna is usually a small fraction (0.1 at most) of a wavelength. The voltage picked up by such a small loop is proportional to the total area enclosed by its turns; i.e., the product of the number of turns by the average area of each turn. For maximum pick up, the turns should be as large as possible, subject to electrical limitations. Most receivers will not operate efficiently from a loop which is self-resonant at any point within the operating frequency range. Consequently, the number of turns must be small enough to keep the natural resonance higher than the highest operating frequency.

3–7. Crossed-Loop Antenna.

a. General. A crossed-loop antenna consists of two loops with identical characteristics, mounted at a fixed angle of 90 degrees to each other. Each loop has a figure-eight response pattern which is displaced 90 degrees in azimuth. As a result, the ratio of the two responses varies with direction. Several different systems have been devised to make use of this fact.

b. The Goniometer. In the Bellini-Tosi system, the two loops are connected to two stator windings, located 90 degrees apart. In operation a goniometer, whose rotor winding is connected to a radio receiver, is turned to a null or a position of minimum output so that its angle corresponds to the direction of the signal picked up by the loops. Since the loops themselves need not be rotated, they can be made large for the sake of sensitivity. The operation of the goniometer will be explained in detail in section III, chapter 3.

3–8. Adcock Antennas.

a. General. An Adcock antenna consists of two spaced vertical antennas connected in

opposition. Theoretically, it responds only to the vertically polarized component of an incoming radio wave, and therefore is not subject to polarization error. In practice, there is some polarization error due to various imperfections, but usually much less than in a loop antenna receiving the same signal. The Adcock antenna is preferable to a loop in radio DF when medium or high frequency signals must be received at a point beyond groundwave range.

b. Principle. The basic Adcock antenna consists of two vertical elements connected as shown in figure 3–19. The action of such an antenna, as far as vertically polarized waves are concerned, is identical with that of the loop antenna. A resultant current in output coil L is proportional to the vector difference of the voltages induced in the vertical members, exactly as in the case of the loop. Horizontally polarized components of descending skywaves do not affect the antenna because of the absence of the upper and lower horizontal members, and because the crossed arrangement of the center members effectively cancels the voltages induced in them. The response pattern of an Adcock antenna is the same figure-eight pattern typical of the loop antenna. Minimum and maximum response points are present in the Adcock pattern in the same respective positions as in the loop pattern. Thus, the directional properties of the Adcock and loop antennas are the same with respect to vertically polarized waves. The effects of various types of wave polarization on the Adcock circuit are as follows:

(1) *Vertical polarization.* The horizontal magnetic field of the vertically polarized wave cuts the two vertical antenna elements. Induced currents, while they are induced in phase in the vertical elements, oppose each other in the antenna coupling coil, producing a resultant voltage which leads the radiation field by 90 degrees. This resultant voltage is proportional to the separation between the two antenna elements along the direction of wave travel. Thus the action of the Adcock antenna system is identical to the action of the loop system, and can be used in conjunction with a sense antenna to obtain a unidirectional pattern.

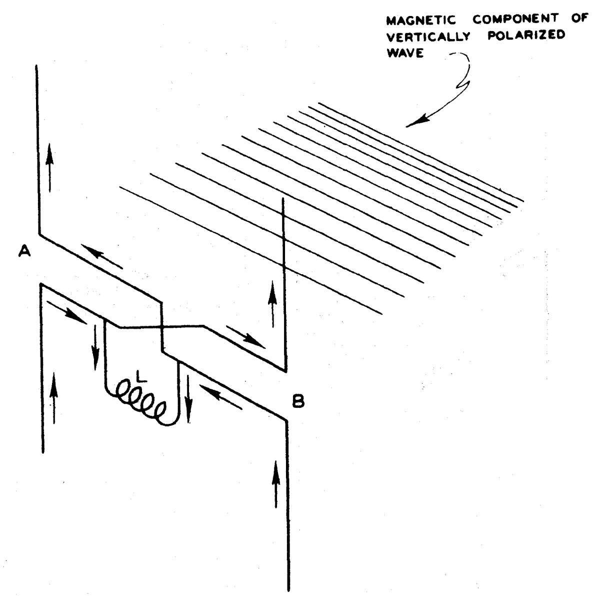


Figure 3–19. Adcock antenna, effects of vertically polarized waves.

(2) *Horizontal polarization.* As shown in figure 3–20, only the horizontal antenna members are in a position to respond to horizontally polarized waves. In a well-designed radio direction-finding system, efficient use is made of shielding and balancing to prevent any voltages induced in the horizontal members from reaching the input stage of the receiver. The residue is small in comparison with the response of a loop under similar circumstances, but it has the same directivity pattern. Thus, the maximum polarization error with an Adcock antenna is still 90 degrees, but is of a lesser magnitude than that of a loop antenna.

(3) *Other abnormal polarizations.* Radio waves usually contain both vertical and

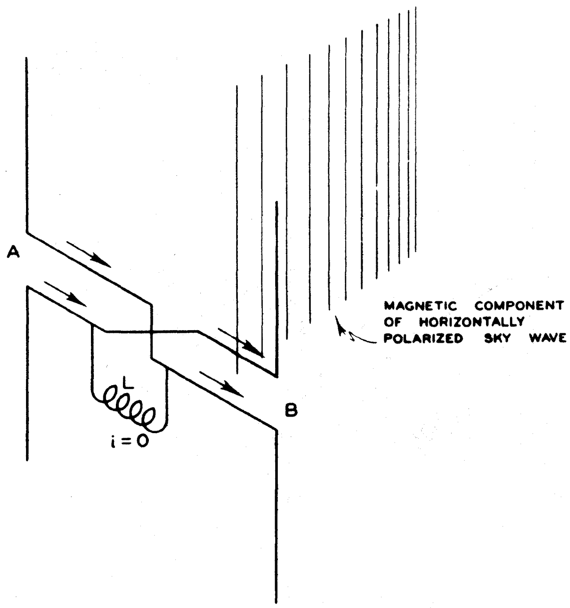


Figure 3–20. Adcock antenna, effects of horizontally polarized waves.

horizontal components of polarization which, in combination, produce an abnormal polarized wave. Although the vertical and horizontal components can be viewed as acting independently, their effect on the antenna is due to the combined action of both components. Because the response of an Adcock antenna is relatively small for the horizontally polarized component, its polarization error is likewise smaller than that of a loop antenna. This is true as long as the vertically polarized component does not entirely disappear. When the vertically polarized component predominates, the Adcock antenna's polarization error is scarcely noticeable.

c. Types. All Adcock antennas have the following general characteristics: first, the active antenna elements are vertically spaced wires; second, the horizontal members are arranged so that little or no voltage can be induced in them; and third, the small voltage that is induced cancels across the output. The various types of Adcock antennas are:

(1) *Simple U-Adcock antenna.* This is the basic type of Adcock antenna (fig. 3–21). U-Adcock antennas are used chiefly in crossed-Adcock systems, which are nonrotatable.

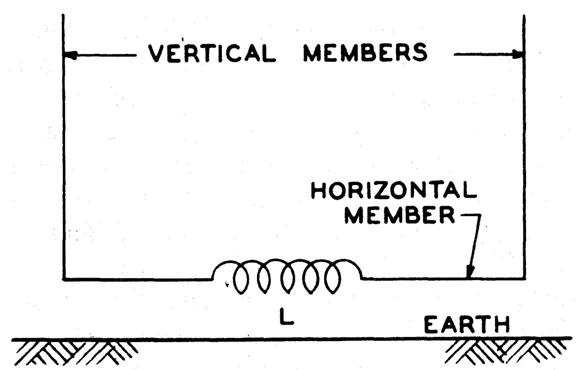


Figure 3–21. Simple U-Adcock antenna.

(2) *Shielded U-Adcock antenna.* The shielded U-Adcock reduces polarization error significantly by shielding the horizontal antenna element. When shielded, its response to horizontally polarized waves is minimized. However, the voltages and currents in the shield set up potentials at the extremities (Capital A, fig. 3–22) which induce voltage into the vertical antenna elements, thus introducing error. Connecting the ends of the shield to metallic plates buried in the ground (Capital B, fig. 3–22) reduces this undesired condition, but introduces another. The shield, ground connections, and earth form an untuned loop which responds to horizontally polarized waves.

(3) *Grounded H-Adcock antenna.* This antenna (fig. 3–23) differs from the others in that its horizontal members are grounded. Directivity, as in the case of the loop antenna, is the result of the differential

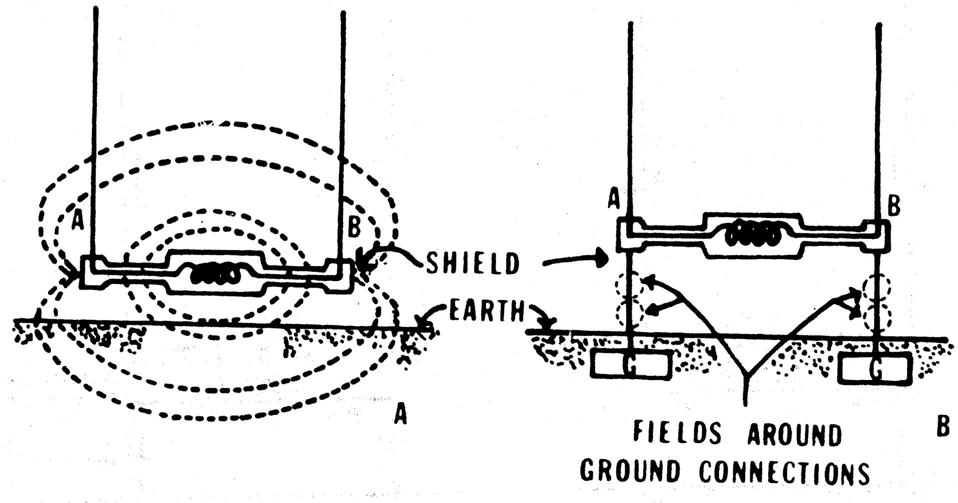


Figure 3–22. Shielded U-Adcock antenna.

action of the voltages in the two vertical antenna elements. The voltages induced in the horizontal antenna elements will cancel. This condition is demonstrated in Capital A, figure 3–23, which shows the distribution of potentials on the horizontal members at a given instant. If equal voltages are induced in all horizontal antenna elements, the resultant voltage across the coil is zero. A problem arises because the lower elements are connected to the ground forming an untuned loop which unbalances the system (Capital B, fig. 3–23). Some of the imbalance can be eliminated by inserting lumped constants in the lower vertical legs (fig. 3–24).

(4) *Elevated H-Adcock antenna.* The elevated H-Adcock minimizes the imbalance caused by grounding the lower portion of the antenna. Balance is obtained through physical symmetry and by raising the antenna a reasonable height above the ground. Depending upon the antenna, balance will be achieved within a fixed height area above the ground. The degree of imbalance increases if the antenna is moved above or below the balance area because of the reduction or increase in antenna-to-ground capacitance.

(5) *Coupled H-Adcock antenna.* This type of antenna incorporates a highly effective method of reducing the pickup of the horizontal antenna elements and reducing polarization error. Azimuth error is minimized by making the impedance of the horizontal elements high to all currents except those induced in the vertical members. The high impedance is obtained by inserting two mutually coupled impedances in each vertical element (fig. 3–25). This method presents a high series impedance (very small capacitance between windings) to all current directly induced in the horizontal elements; however, a low impedance is presented to the voltages induced in the vertical elements since they are mutually coupled through the transformer and appear directly across the antenna coil. A further reduction in polarization error is obtained by carefully balancing the system of the balanced-coupled Adcock antenna (fig. 3–26).

d. Tilting Adcock Antenna. Compared to the loop, the Adcock antenna system is

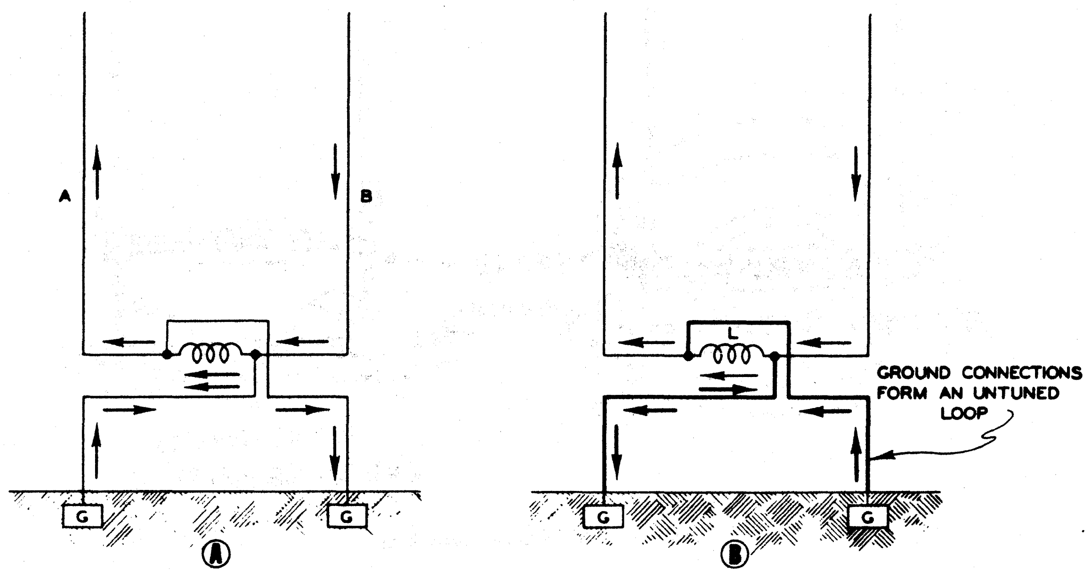


Figure 3–23. Grounded H-Adcock antenna.

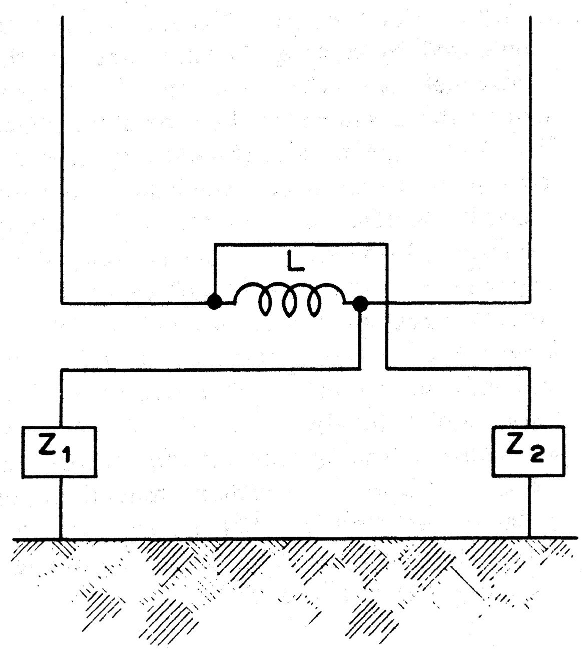


Figure 3–24. Balanced H-Adcock antenna.

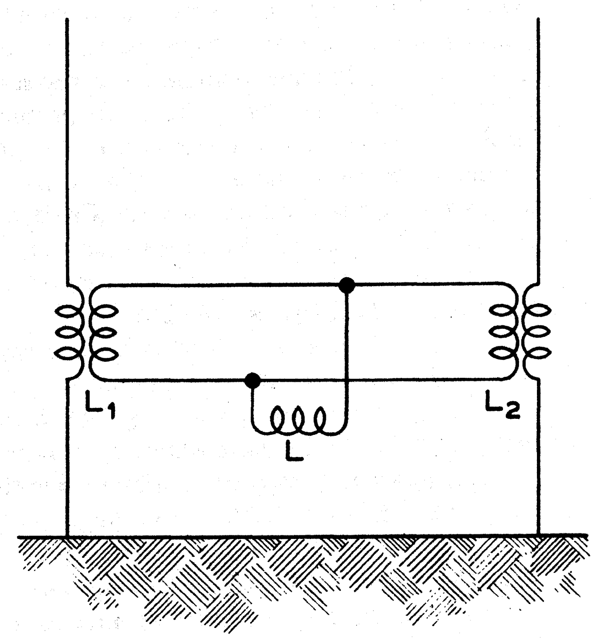


Figure 3–25. Coupled H-Adcock antenna.

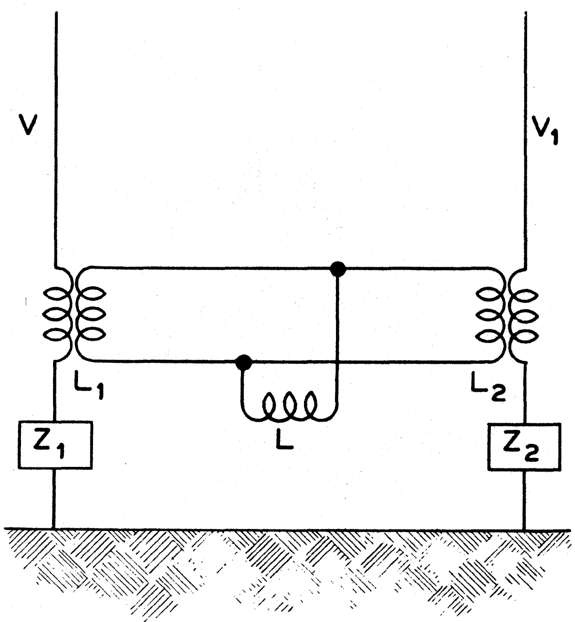


Figure 3–26. Balanced-coupled Adcock antenna.

insensitive to high angle radio waves, even if they are vertically polarized. There are two reasons: first, the spacing of the vertical antennas along the path of a radio wave (Capital A, fig. 3–27) grows smaller as the elevation angle increases or the incidence decreases; second, the effective length of each antenna, in the direction of the lines of electric force of the radio wave, is decreased by a similar factor as these lines tilt forward. The effective length reduction can be overcome by tilting the antenna backward, as shown in Capital C, figure 3–27, until it is perpendicular to the direction of the incoming waves, and therefore parallel to the lines of electric force. Tilting improves the system sensitivity when the Adcock antenna is near the direct azimuth. Conversely, sensitivity decreases near the reciprocal azimuth, since the tilt there is the wrong way. Sense indication also deteriorates because the phase relation between voltages from the Adcock and sense antennas changes unless the sense antenna is also tilted. An Adcock antenna tilted 60 degrees from the vertical might be advantageous for aural-null DF on skywaves from a transmitter 80 to 320 kilometers away, or on signals from a high-flying aircraft 16 to 32 kilometers away, for which the elevation angle may be 45 to 75 degrees.

3–9. Adcock Antenna Errors.

The factors leading to undesired effects and incorrect azimuths when an Adcock antenna is used are similar to those encountered in loop installations. For errors involved in weak signals, antenna effect, and polarization error, see paragraph **3–7.** The causes of imbalance (antenna effect) as it applies specifically to Adcock antennas are:

a. The terrain surrounding a radio direction finder is an important factor in obtaining accurate azimuth readings. To obtain the highest degree of accuracy, a DF set should always be operated on level ground, free from neighboring objects such as telephone lines, power lines, buildings, and metallic masses. The presence of such objects or peculiarities in the terrain may cause an imbalanced condition (antenna effect) to exist at the antenna, resulting in possible error. The antenna effect can be reduced by using a stationary Adcock; thus, the relation of the antenna to the ground and nearby objects is fixed, making the final problem of correction less difficult.

b. With a U-Adcock, irregularities in the ground at the base of each monopole may unbalance the system. This effect can be materially reduced with a counterpoise covering the ground between the spaced monopoles and extending beyond them a considerable distance in all directions.

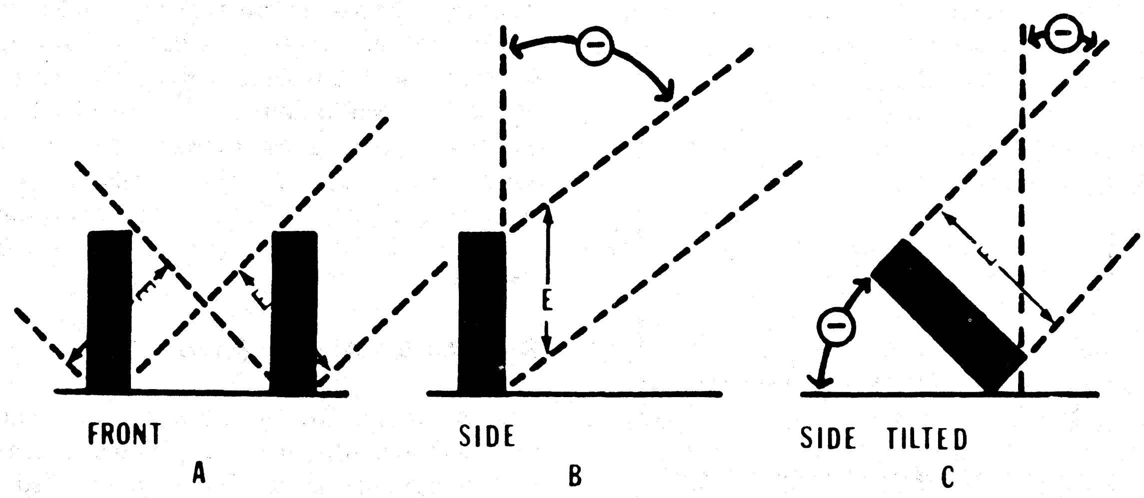


Figure 3–27. Effects of tilting an Adcock antenna.

c. With an elevated H-Adcock antenna, the mere existence of the ground causes a slight imbalance, and any conductors on the ground will make the imbalance worse because the lower ends of the dipoles are naturally closer to the ground than are the top ends. This imbalance leads to polarization error, rather than antenna effect. The difference between the ground is so far away, and the antenna effect resulting from it is rarely, if ever, perceptible.

d. In both types of Adcock systems, shielding of the horizontal transmission lines is useful and sometimes an indispensable guard against imbalance caused by adjacent objects (such as the DF operator). It also eliminates accidental capacitive coupling to other circuits in the vicinity.

e. Another important point in reducing antenna effect is to maintain perfect symmetry and spacing of the antenna elements. Imbalance is caused by having one element slightly larger than the corresponding one, or by having nonuniform spacing. Coupling coils must be identical in inductance and the number of couplings must be equal.

f. Antenna spacing in a rotatable H-Adcock system may be almost a full wavelength before the directional pattern becomes unusable. At spacing exceeding 1/2 wavelength, the figure-eight pattern has a dimple in the middle of each lobe, which deepens with increasing frequency, becoming a null when the spacing reaches a full wavelength. Even then the antenna still has directional properties, but the extra nulls make interpretation difficult.

3–10. Crossed-Adcock Antennas.

a. General. A crossed-Adcock antenna consists of two identical Adcock antennas, oriented 90 degrees apart in azimuth. Crossed-Adcock antennas may be used in various ways similar to those mentioned in paragraph **3–7***a*. At low and medium frequencies, crossed-Adcock antennas can be made much larger than rotatable Adcock antennas, and are therefore more sensitive. At high frequencies, this advantage is small because of the limitations imposed by spacing effect or octantal error (para **3–19**).

b. Spacing. In a crossed-Adcock system, the maximum spacing is one-half wavelength between adjacent antennas (0.707 wavelength between diagonally opposite antennas). Above this limit, the same indication may be obtained for signals coming from three different directions (six before sense determination).

3–11. Spaced-Loop Antennas.

a. General. The spaced-loop antenna consists of two parallel loops fixed to the ends of a boom which may be rotated about its center or on other "platforms" (various types of aircraft). Earlier models of DF equipment using spaced-loops had the loops mounted perpendicular to the boom, and were said to be coaxial. Since the two loops point in the same direction, the magnitude of the output voltage of each loop will vary in the same manner as the loop is rotated. Besides the normal loop directivity, the spaced-loop system has directivity due to the loop spacing; the latter directivity is not affected by polarization errors. There are two addditional types of spaced-loop antenna systems called the vertical coplanar and the horizantal coplanar (fig. 3–28).

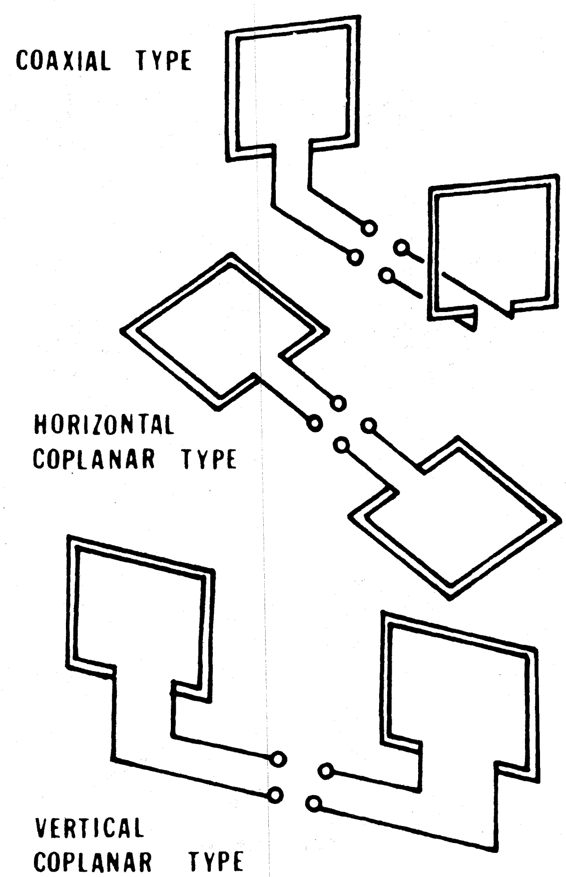


Figure 3–28. Common spaced-loop types.

b. Pattern for Vertically Polarized Waves. The pattern for the coaxial spaced-loop system (Capital A, fig. 3–29) has four nulls spaced 90 degrees apart when vertically polarized waves are received. Two of the nulls occur when the planes of both loops are perpendicular to the direction of wave travel; the other two occur when the planes of both loops are parallel to the direction of wave travel. Although maximum signal is induced in both loops when their planes are parallel to the direction of wave travel, the outputs of both loops are in opposition and cancel across the antenna coupling coil. In this case, the wave strikes both loops at the same instant. If the boom is rotated, less voltage is induced in each loop. The wave will strike one loop before it strikes the other, producing a resultant voltage across the antenna coil. If the boom is rotated 90 degrees, the separation between the two loops is maximum. Maximum voltage would be expected to appear in the output, however, this expected result does not occur. When the boom is rotated 90 degrees, each individual loop is perpendicular to the direction of wave travel, and there is no voltage induced in the loops. Therefore, there is a null point every 90 degrees. One set of null points results from the position of the individual loops, the other set from the position of the boom. There is a maximum point located between each

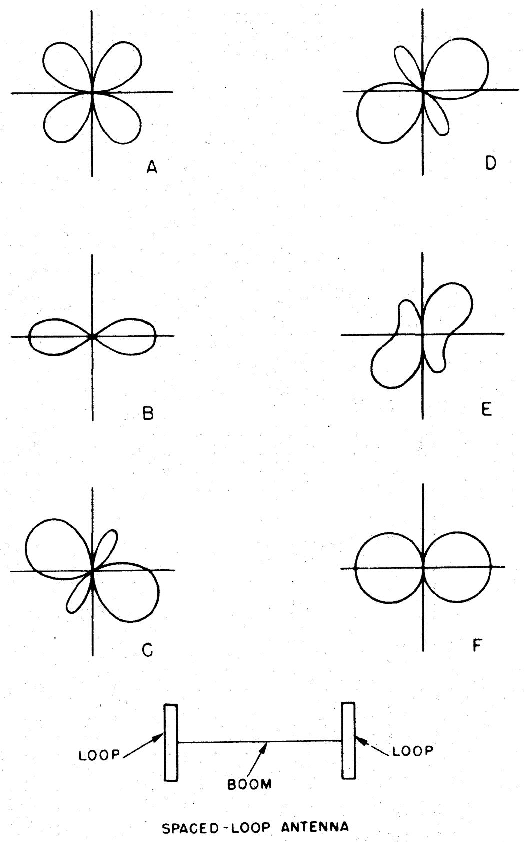


Figure 3–29. Spaced-loop antenna response patterns.

adjacent pair of nulls when both the plane of the loops and the antenna boom are at a 45 degree angle with respect to the null position.

c. Patterns for Abnormally Polarized Waves. Capitals B through F, figure 3–29, show typical response patterns obtained with a spaced-loop antenna (coaxial) when the polarization of the received waves is other than vertical.

(1) Capital B, figure 3–29, closely resembles the response pattern for a wave which is horizontally polarized. This type of polarization is rarely encountered. The pattern is similar to a flattened figure eight.

(2) Capitals C and D, figure 3–29, show the distortion which occurs when the received waves contain both horizontal and vertical components of polarization. Note that two of the nulls are shifted in azimuth, while the other two nulls remain unaffected.

(3) Capitals E and F, figure 3–29, show typical patterns which may be obtained when receiving elliptically polarized waves (waves containing both horizontal and vertical components which are out of phase with each other).

d. Polarization Error. It is important to note that regardless of the polarization of the received wave, two of the nulls (or minimums) are affected by polarization and shift as the polarization changes. Thus the spacing nulls are free from polarization error, while the loop nulls are subject to it, just as in a single-loop antenna.

e. Taking an Azimuth. The correct null must be used when taking an azimuth with the spaced loop. Receiving a skywave or any other type of abnormally polarized wave, the correct set of nulls appear fixed, while the pair affected by polarization error is indefinite or continually shifting in position. The direct and reciprocal bearings of the correct set of nulls can be determined if the general direction of the transmitter is known, or if a bearing is taken by a loop and sense antenna combination to determine general direction. When the radio wave is vertically polarized and has traveled only a short distance, definite and fixed nulls are found every 90 degrees. The general direction of the transmitter must then be known by other means before the correct null can be selected. When azimuths from several DF sites are plotted on a map, the direct azimuths will intersect near the transmitter location, while reciprocal azimuths and false azimuths (from loop nulls) will either run off the edge of the map without intersection, or intersect at widely scattered points.

3–12. Theory of Doppler Direction Finding.

A signal which is received by a moving antenna will experience a phase modulation in accordance with Doppler's principle. The radiation field has an "equiphase surface" or "wave front" which is equidistant from the transmitter at all points along the wave front. When a receiving antenna is placed in rotational motion about a reference point (fig. 3–30), the signal processed by the receiver will exhibit a sinusoidal phase modulation or frequency change. As the antenna is moved from 0 to 180 degrees, the receiver will experience a frequency decrease because the antenna is moving away from the incoming wave front. When the antenna continues from 180 to 360 degrees, which is toward the incoming wave front, the receiver experiences a frequency increase. No frequency change or phase modulation will be experienced at the direction from which the wave front came nor at the back azimuth (180 degrees opposite). Measurement of this modulated frequency permits the arrival direction of the signal to be determined. This type of system is used in Airborne Radio Direction Finding (ARDF).

3–13. Quasi-Doppler Direction Finding.

The Quasi-Doppler direction finder locates a wave front or plane and the direction from which it was transmitted is assumed to lie perpendicular to it.

a. Theory. Radio waves travel outward in space from a transmitting antenna at the speed of light and have the same phase at all points which are equidistant from the transmitting antenna. A wave front arriving at two or more distant points simultaneously (Capital A and D, fig. 3–31) is said to be in phase and lie on an imaginary wave front. All points along this wave front are equidistant from the transmitter. Wave fronts in free space are always spherical since all points equidistant from a single point must lie on the surface of a sphere. This point, the center of the imaginary sphere, is the transmitter site.

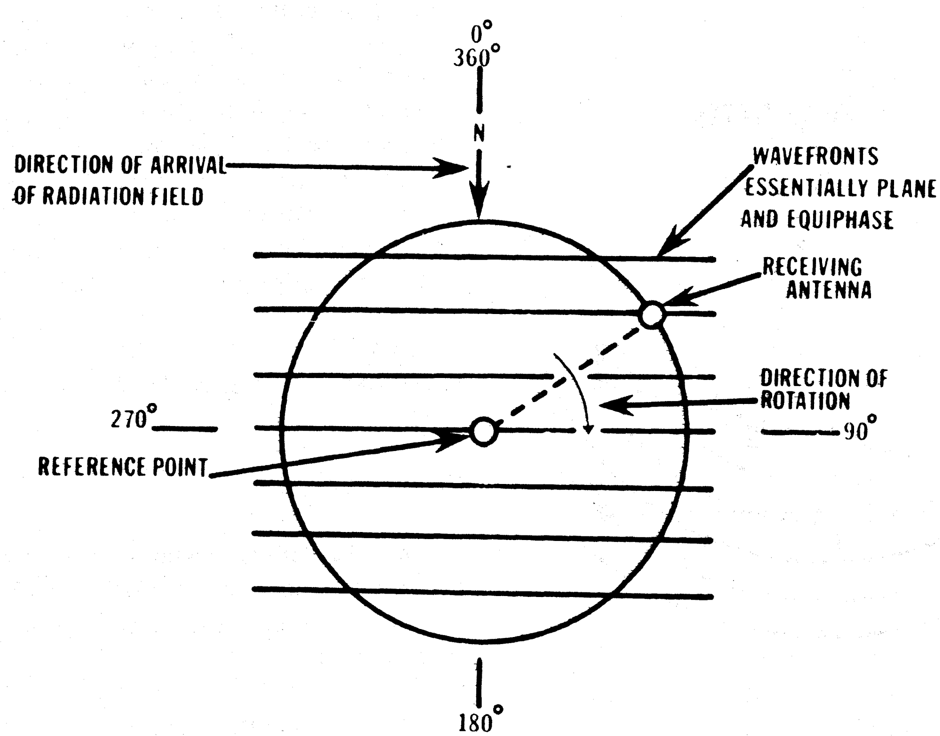


Figure 3–30. Doppler direction finding.

The spherical curvature of the wave front is quite pronounced near the transmitter site, but at greater distances, the curvature is so slight that the wave front may be considered to be a plane surface (Capitals A and D, and E and H, fig. 3–31). A line perpendicular to and bisecting the middle of this plane or wave front between two known points will pass through the transmitter site (Capitals B and C, and E and G, fig. 3–31).

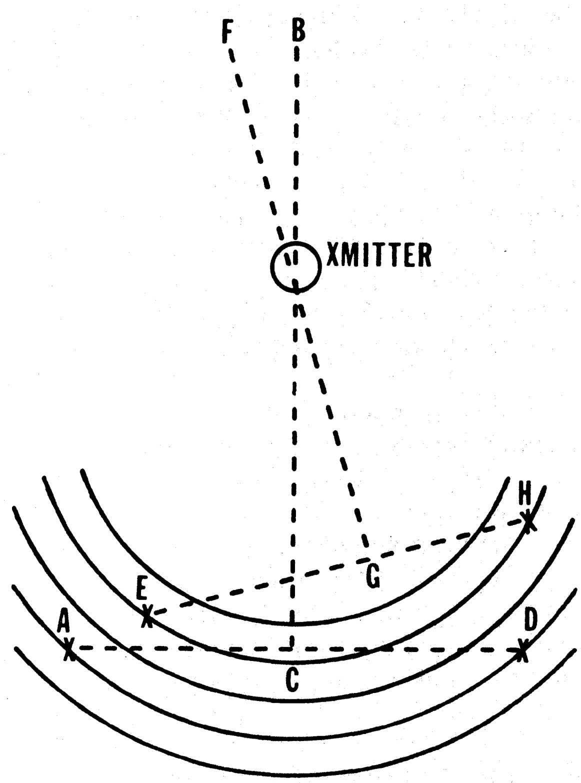


Figure 3–31. Transmitter lies along a line perpendicular to the wave front.

b. Principle of Operation. The Quasi-Doppler direction finder is similar to Doppler direction finding. Instead of physically rotating an antenna through the radiation field, the function is simulated by sampling the outputs of several fixed antennas spaced equally around a circumference equal to that normally traced out by the rotating antenna (fig. 3–32). As long as the number of antennas is sufficient to satisfy the sampling requirement, this system permits the determination of the transmitter's direction by construction of an imaginary plane or wave front (fig. 3–33). The arrival direction of the transmitted signal lies on a line that bisects the middle of, and is perpendicular to, this plane.

Section II
TRANSMISSION LINES

3–14. Transmission Lines Used with DF Equipment.

Transmission lines and coupling systems used to tie the actual DF equipment to the antenna system are very closely interrelated. To attempt to separate the information relating to transmission lines and coupling systems would not be in the best interests of this manual. Accordingly, information pertaining to transmission lines will be included in the following section on coupling systems.

Section III
COUPLING SYSTEMS FOR DF EQUIPMENT

3–15. General.

a. Coupling systems are defined as those elements of a DF system which serve to couple the directional antenna system to the radio receiver.

b. The coupling system must fulfill the following requirements for satisfactory operation:

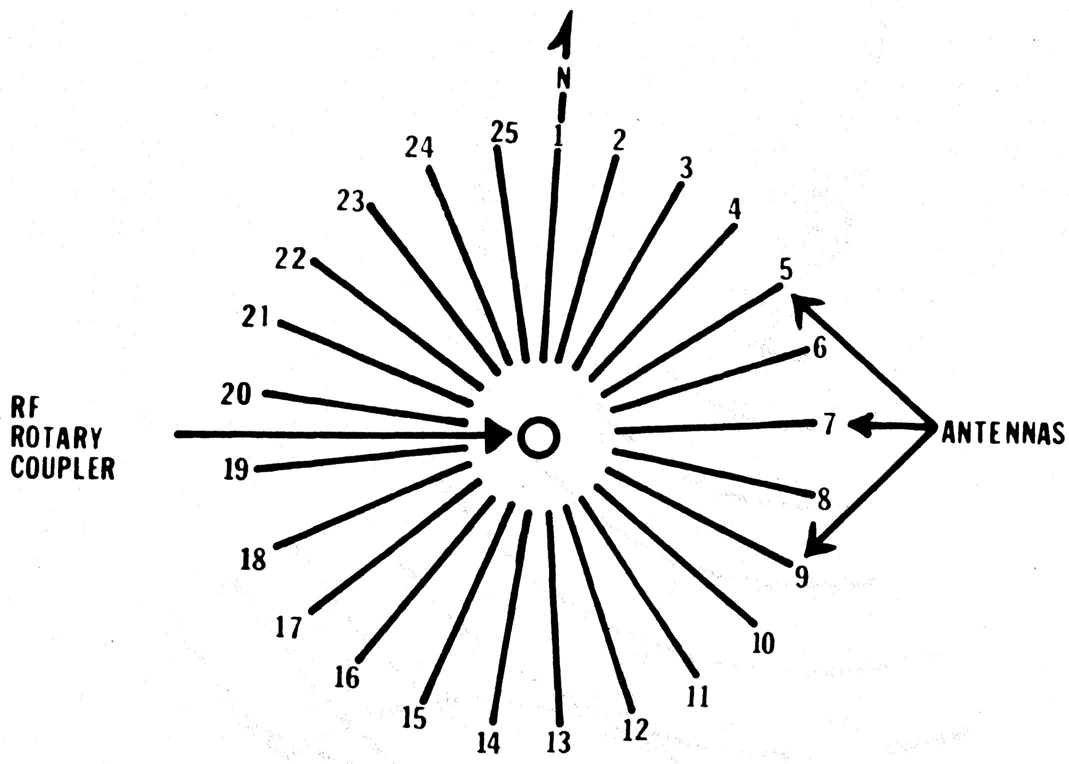


Figure 3–32. Quasi-Doppler direction finder antenna array.

(1) It must efficiently conduct the energy picked up by the antenna system to the radio receiver. If this requirement is not met, the DF will lack sensitivity.

(2) It must not pick up or otherwise introduce additional energy from the wanted signal. Failure to meet this requirement results in bearing errors.

(3) It must not introduce unwanted signals or noise. These effects, if present, produce interference and impair the bearing accuracy.

c. Coupling systems, as used in various types of DF equipment, differ in complexity and type. Common types in general use are discussed individually in two categories:

(1) Systems used with rotatable antennas.

(2) Systems used with fixed antennas.

3–16. Coupling Systems Used with Rotatable Antennas.

a. Direct Coupling. Direct coupling, as the name implies, is the simplest form of coupling. The antenna terminals are directly connected to the receiver input. It is used in those few cases where it is practical to design a DF system in which the radio receiver is located at the antenna terminals, and the antenna and receiver rotate together as a unit. Other directly coupled DF sets are small, hand-carried, transistorized receiving sets used by counterinsurgency personnel. The loop is generally the carrying handle, and the entire set is rotated to produce line bearings in the direction of the target transmitter.

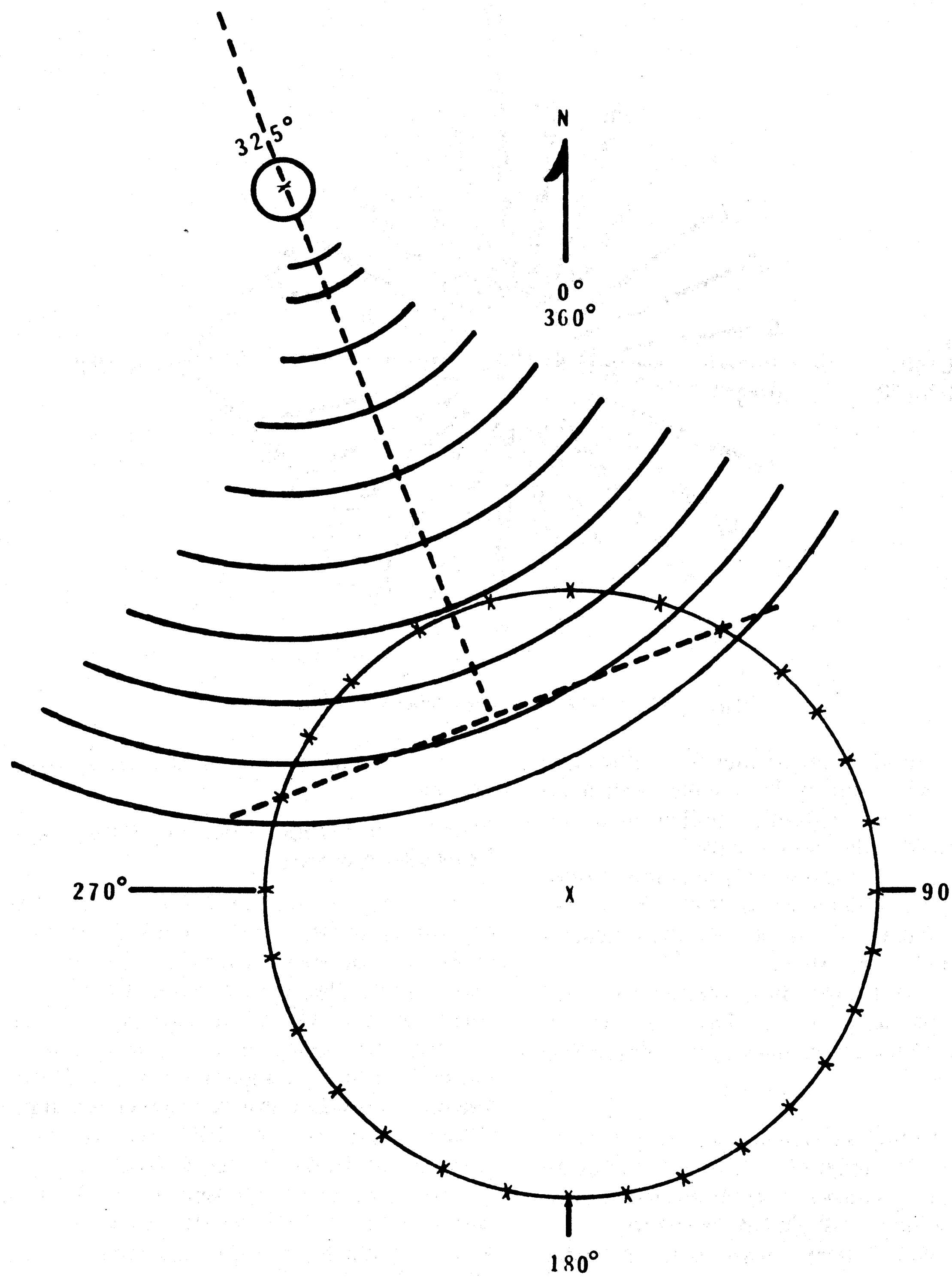


Figure 3–33. Direction finding by a Quasi-Doppler system.

b. Transmission Line Coupling. Transmission line coupling is used in its simplest form on DF sets in which the antenna system is placed some distance above, but is rotatable with its radio receiver.

(1) Construction of a transmission line coupling system is extremely simple. It is usually made up of a length of balanced, dual-conductor, shielded Radio Frequency (RF) cable, or two balanced lengths of single-conductor, coaxial, shielded cable. However, these place stringent requirements on its design since, by virtue of its length and position, the transmission line will, if its shielding or balance is not perfect, introduce unwanted energy causing bearing errors or impaired readability. In addition, if the length of the transmission line is an appreciable fraction of a wavelength or more, its characteristic impedance must accurately match the impedance of the receiver and the antenna, or a considerable loss of sensitivity will occur. In cases where the transmission line is short, such matching is not essential. However, the series impedance of the line must be small and its leakage impedance great in comparison with the sum of the antenna and receiver input impedances.

(2) The direct and transmission line systems of coupling the antenna to the receiver may be used when it is desired to rotate the antenna without rotating the receiver. This is accomplished by the addition of a rotatable coupling element. Several types of rotatable elements used in various DF sets are:

(*a*) *Slip rings.* Slip rings are insulated metal rings, in contact with sliding fingers or brushes, which permit rotation without interrupting the circuit. By mounting the rings on a shaft and providing fixed brushes, it is possible to conduct the antenna current to a stationary receiver while permitting the antenna to turn at will. It is customary to make the rings of silver and the brushes of a silver alloy which is either harder or softer than the rings in order to minimize the variation of contact resistance as the rings are rotated. Such variations give rise to noise which is amplified in the radio receiver and may obscure the wanted signals.

(*b*) *Rotating transformer.* This rotatable coupling device consists of a transformer whose primary and secondary windings are coaxial. Under this condition, one winding may be rotated with respect to the other without changing the coupling which exists between them. This type of rotatable coupling device can serve as the input transformer of the DF receiver, with the secondary coil turned over a limited frequency range in unison with the rest of the receiver circuits. It can also be used for relatively wide frequency coverage in those cases where its primary and secondary load impedances are substantially uniform and resistive in nature.

(*c*) *Rotating capacitor.* This form of rotatable coupling element makes use of the fact that the capacitance between coaxial disks or rings is independent of their rotation. This method is customarily used only in VHF equipment since only a small value of capacitance is achievable with elements of reasonable size. At these frequencies, a small capacitance can provide adequate coupling.

3–17. Coupling Systems Used with Fixed Antennas.

In DF, the term goniometer is applied to a device used to couple two or more input circuits (usually connected to antennas) to an output circuit (usually connected to the radio receiver). This is done in such a manner that the degree of coupling varies with the rotation of a shaft. The coupling between one input circuit and the output circuit increases, while the coupling with the other input circuit decreases. When properly connected, a well-constructed goniometer provides an output, at each position of its shaft, identical to that which would be produced by a single

figure-eight pattern antenna oriented to the corresponding position. Thus, the goniometer provides an equivalent for the rotation of an antenna, and makes it possible to use large fixed antenna systems (either loop, Adcock, Circularly Disposed Antenna Arrays (CDAA), or others) which would in themselves be too bulky for an operator to rotate.

a. Inductive Goniometer. The inductive goniometer usually consists of two fixed windings arranged at right angles to each other and inclosing a third winding which is rotatable by means of a shaft (fig. 3–34).

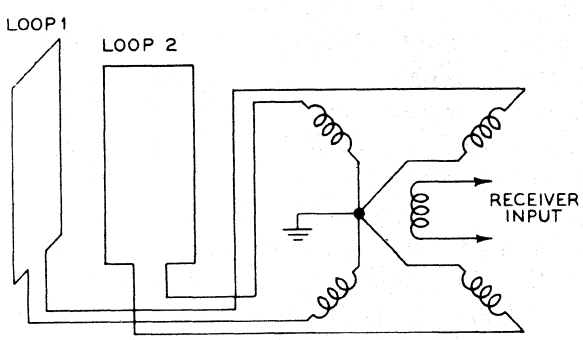


Figure 3–34. Basic goniometer circuit.

(1) When the two fixed windings, arranged at right angles, are connected to identical antennas having figure-eight patterns, the magnetic field within the goniometer will have a direction in relation to the fixed windings corresponding to the direction of arrival of the signal at the fixed antennas. As the internal winding, or search coil, of the goniometer is rotated, its output will vary from maximum to minimum twice per revolution, exactly as would the output of one of the antennas if it were rotated. The positions of minimum output, or nulls, are used to determine the bearing in exactly the same way as if a rotatable antenna was used. The goniometer may be rotated by hand, thus providing manual null-seeking, or it may be continuously rotated by a motor drive and employed with an automatic visual bearing indicator.

(2) The effect of changing the direction of wave travel on the directional pattern of the goniometer system is shown in figure 3–35. The first column shows the position of the transmitter with respect to the loops, the second and third columns show the position of the goniometer rotor for maximum and minimum signals at each transmitter position, and the fourth column shows the position of the indicator pointer when the DF is set on the correct azimuth.

b. Capacitive Goniometer. The capacitive goniometer consists of two fixed sets of capacitor plates inclosing a rotatable set of plates. Operation of this type is similar to the inductive goniometer except that an electric field rather than a magnetic field is established within the goniometer. In practice, the capacitive goniometer is usually used at frequencies above 100 MHz since it is difficult to construct accurate and efficient inductive goniometers for these frequencies.

c. Requirements. In order to minimize errors, it is necessary to construct goniometers with extreme precision. The basic requirements for accuracy in a goniometer coupling system are:

(1) The fixed elements must be electrically identical.

(2) There must be a complete absence of coupling between the fixed elements.

(3) Accurate positioning of the fixed elements at the same angle as the antennas (usually 90 degrees) is necessary.

(4) Coupling between the rotating element and the fixed elements must vary with shaft revolution in accordance with the same law as the variation of antenna response with azimuth angle. Generally, this means cosine-law variation.

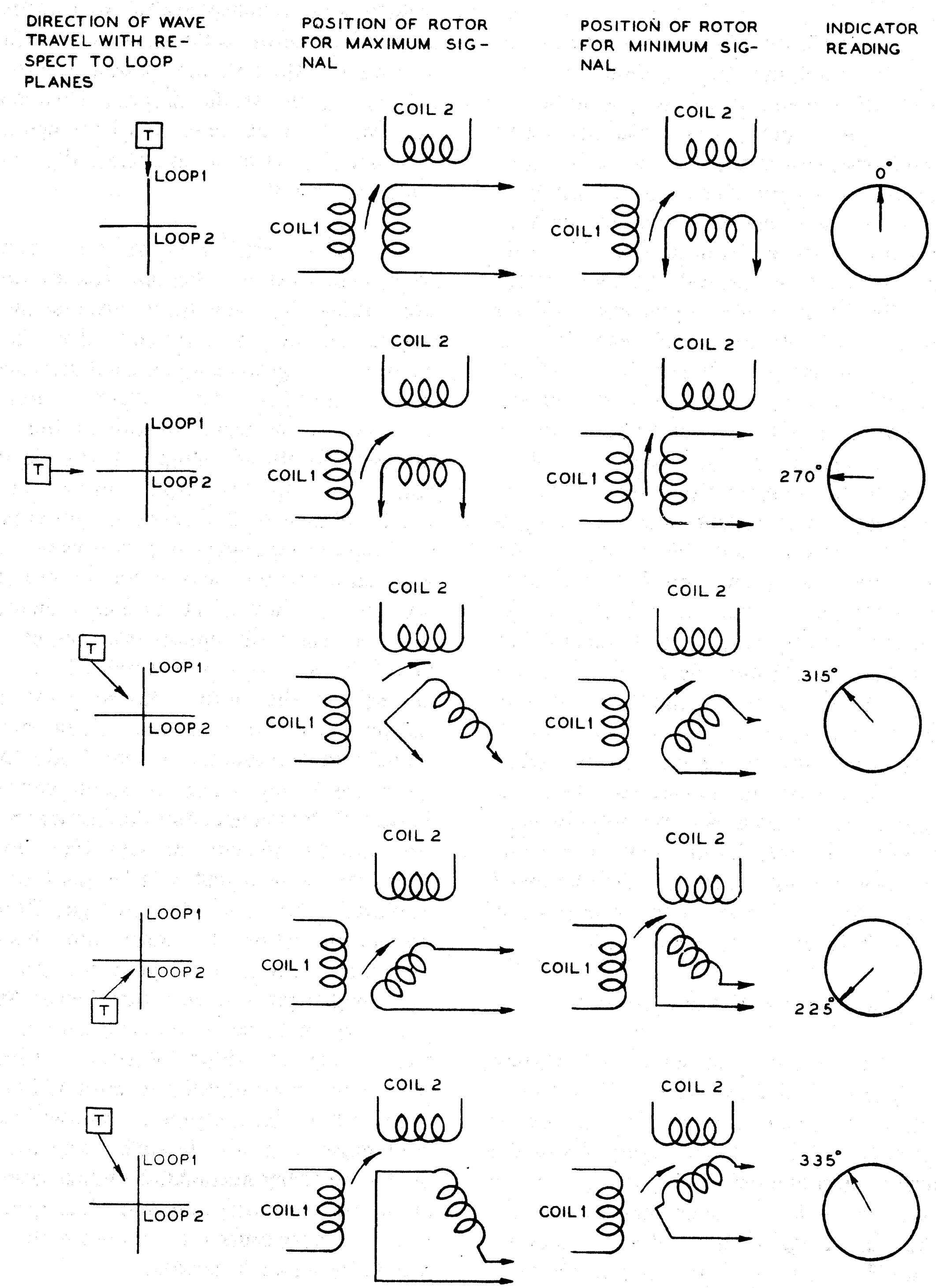


Figure 3–35. Goniometer system, directional characteristics.

Note: These requirements are met in practical goniometers to the extent that the maximum error is less than ± 1 degree.

d. Transmission Lines and Coupling Devices. In applying the goniometer to a practical DF system, it is often desirable to locate the goniometer some distance away from the antenna system. To accomplish this, it is necessary to provide transmission lines between the antenna and the goniometer. These lines must be well shielded and are usually balanced to ground to avoid stray pickup. In addition, the transmission lines connecting the several antennas to the goniometer must be electrically identical, particularly in time delay, over the entire frequency range of the equipment in order to preserve accuracy and provide deep nulls. Such systems customarily use shielded, balanced-type transmission lines laid on the ground. The antennas may be coupled to the transmission lines either through transformers designed to match the impedance of the antenna to the impedance of the transmission line or through amplification type coupling devices. The transmission line length is also critical as varying lengths will cause varied signal strengths to be received. Transmission line coupling must be precise and balanced throughout the system. All couplings must be clean and have maximum contact, if not, signal loss will result. A transmission line with three couplings will have a greater amount of signal loss than a line with two couplings.

3–18. Electronic Goniometer System.

a. This system, in which the varying coupling is provided by means of electronic circuits rather than by mutual inductance or capacitance, is an electronic equivalent of the inductive goniometer. In practice, it is desirable to make the electronic goniometer circuits an integral part of the antenna system. However, the electronic goniometer may be considered as a coupling system applicable to the same forms of antenna systems as the inductive and capacitive goniometers. The electronic goniometer system is particularly useful with automatic bearing indication systems, since the effective rotation of the antenna system is produced entirely by electronic circuits. This permits the use of high speeds which would be unattainable with a mechanically rotated inductive circuit.

b. The basic unit of the electronic goniometer system is the balanced modulator. This device has two input circuits and one output circuit so arranged that if two different voltages are introduced into the two input circuits, the output voltage is proportional at every instant to the vector produced by these voltages. In the electronic goniometer, the two input voltages are the signal voltages picked up by the antenna and an Audio Frequency (AF) sine wave voltage of a frequency representing the desired rate of effective rotation of the antenna. The output of the balanced modulator, under these conditions, is a modulated envelope comprising the entire spectrum of signals picked up by the antenna. Each signal is completely modulated in amplitude by the audio frequency used. In other words, the output of the balanced modulator contains all the signals picked up by the antenna. However, each signal is varied periodically in amplitude by the AF voltage from its maximum value to zero and back to maximum with reversed polarity, just as if a figure-eight pattern were rotating at the AF rate. Two balanced modulators, upon having their outputs added together, form an electronic equivalent of the spinning inductive goniometer. The outputs of the two balanced modulators combine in such a way that each of the resulting modulated signals reaches its minimum or null at an instant during each AF cycle, corresponding to the direction from which the signal is arriving.

3–19. Octantal Error.

a. In addition to the errors common to the type antenna used, another error, known as octantal error, is introduced by the goniometer. This is caused by the nonuniformity of the flux fields within the stationary windings of the goniometer. In early types of goniometers, this nonuniformity was considerable and, as a result, octantal error was large. In more modern goniometers, however, the turns of both the stator and rotor windings are distributed in such a manner that almost perfect uniformity of the flux fields is obtained. Thus, this type of octantal error is practically eliminated.

b. Octantal errors are also introduced by the physical dimensions of the antenna system as related to the ground. When the spacing of the antenna elements is large with respect to wavelength, the relation between the planes of the antenna elements and the direction of wave arrival does not parallel at all points the relation between the goniometer rotor and the goniometer stationary windings. Instead, the true azimuth is found by adding a correction factor to the azimuth reading. Since the element spacing becomes increasingly longer with respect to wavelength as the frequency is increased, the correction also becomes greater. Generally, an octantal correction chart is supplied with the equipment.

Section IV
BEARING INDICATORS

3–20. Definition and General Characteristics.

a. After energy has been picked up by the antenna, passed through the coupling system, and amplified by the receiver, the bearing indicator translates this energy into an intelligible form from which the operator can determine the direction of the arriving signal. In addition, a bearing indicator may provide information enabling the operator to choose the most satisfactory moment to read the bearing and to judge the probable accuracy of that bearing.

b. The type of bearing indicator used with any particular DF system depends on the type of DF system in use, the complexity and physical size permitted, and the accuracy desired for a particular DF application.

c. Many types of bearing indicators have been designed and used in DF systems, but those having greatest application can be grouped in the following general categories:

(1) Aural indicators.

(2) Instantaneous indicators (scope presentations).

(3) Automatic bearing-seeking indicators (primarily in airborne application).

(4) Digital read out.

d. Each type of indicator has certain specific characteristics and applications which are described in detail in this section. Many of these characteristics are closely related to, and cannot be separated from, characteristics of the DF system with which a particular indicator is used. For example, in an instantaneous DF system, many of the features exhibited by the indicator are not necessarily characteristic of the indicator alone, but are the combined characteristics of the antenna, coupling, and indicator system.

3–21. Aural Null.

An aural null is the decreased audio tone of the received signal when the antenna is at right angles to the arriving wave front and the signal components (phase relationship and signal strength) are identical. Electronically, when signals of equal value are "beat" (mixed together), these signals will, among other effects, cancel each other. This cancellation results in the decreased audio tone.

a. *Aural Indicator.* An aural indicator is a headset or loudspeaker connected to the DF

receiver audio circuit. It enables the operator to detect the signal bearing by changes in the audible receiver output as the antenna is rotated. In DF systems using aural indicators, the antenna system must be rotated to the bearing position. This position must be characterized by an abrupt change in the antenna response pattern and, therefore, in the receiver output.

b. Types. In the most common DF sets using aural indicators, the antenna is a rotatable loop or Adcock, or a fixed crossed-loop or crossed-Adcock effectively rotated by a goniometer. All these antennas have, or result in, a figure-eight response pattern with broad maximums and sharp nulls. Therefore, the nulls of the antennas are selected as the bearing points. Aural indicators used with DF sets having these types of antennas are commonly called aural-null indicators. At the higher frequencies (several hundred megahertz), directional arrays having response patterns with sharp maximums can be used. Aural indicators operating with these antennas might be called aural-maximum indicators. The remainder of this paragraph is limited to a discussion of aural-null indicators rather than aural-maximum indicators because they are the most common in DF equipment currently deployed.

c. Characteristics. The important characteristics of the aural-null indicator are as follows:

(1) It is the simplest indicator that can be used with a DF set since:

(*a*) It adds nothing to the DF because a headset or speaker is usually included for monitoring purposes.

(*b*) It can be used with simple-loop or Adcock antenna systems without the addition of complicated coupling systems.

(*c*) It reduces to a minimum the size, weight, and maintenance factors of the indicator.

(2) The indicator cannot detract from the accuracy of the remainder of the system.

(3) The readability of the indicator is not influenced by the type of signal received, whether it is Continuous Wave (CW), Interrupted Continuous Wave (ICW), or Modulated Continuous Wave (MCW).

(4) The readability of the indicator is high on weak signals in the presence of noise or interfering signals because the human ear can differentiate between desired and undesired signals.

(5) The readability of the indicator is poor on fading signals because it cannot discriminate between a fade and a null indication.

(6) An extra operation must be performed to determine sense.

3–22. Visual Bearing Indicator Systems.

More sophisticated equipment is required for systems providing visual bearing presentations. A meter or oscilloscope must be used to determine the bearing direction. Most DF equipment currently deployed has a scope integral to the circuitry. On the scope face, the signal bearing is displayed in a number of forms or shapes.

a. Instantaneous (Oscilloscope) Indicators. An instantaneous visual indicator using a Cathode-Ray Tube (CRT) continuously and automatically presents a pattern or trace on the tube screen that points toward the azimuth of the arriving signal or an azimuth scale around the face of the tube (fig. 3–36). The presentation of this pattern or trace is accomplished without manually rotating the DF antenna to the bearing position.

b. Application. The application of an instantaneous indicating device to a DF system is possible only if the antenna system is one of the following types:

(1) A fixed, oriented, crossed-loop, or crossed-Adcock variety that may be effectively rotated 360 degrees at a constant rate by a spinning mechanical or electronic goniometer.

(2) A fixed, oriented, crossed-loop, or crossed-Adcock variety, the outputs of each of the crossed-loop or Adcock antennas maintained as separate signals through a dual-channel receiver, or through a system of antenna switching and a single-channel receiver, to individual channels in the indicator.

(3) A single-loop or Adcock that is continuously rotated 360 degrees by mechanical means at some constant rate.

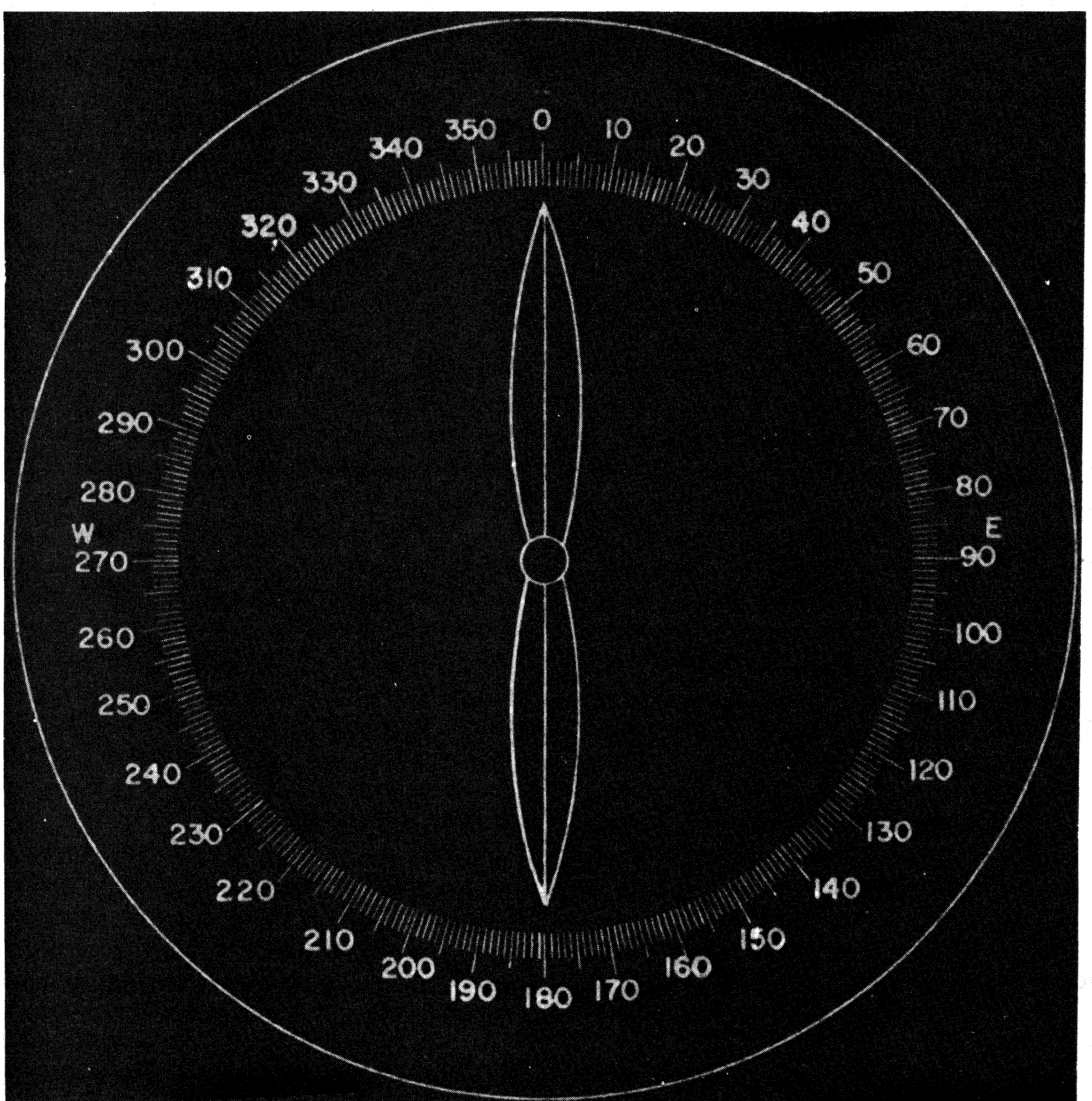


Figure 3–36. Typical position of azimuth scale on instantaneous indicator (oscilloscope).

(4) A Circular Disposed Antenna Array (CDAA) equipped with monitor beams, power combiners, and much greater sophistication than has thus far been discussed.

(5) Inverse LORAN.

(6) Single Site Position Assembly Location.

c. Characteristics. Because these special features must be incorporated in a DF system using an instantaneous indicator, its size, weight, power consumption, complexity of design, and maintenance are greater than in systems using aural-null indicators. When not prohibitive, these disadvantages are more than compensated for by the increased performance obtained when using this type of indicator. Characteristics of instantaneous indicators in comparison with similar characteristics of aural-null indicators are as follows:

(1) There is greater speed in obtaining bearings because the antenna is not manually rotated to the bearing position. Bearings can be taken as quickly as the receiver can be turned to the desired signal and the bearing read directly from the indicator. In autotune systems the productivity of a remoted DF site is greatly increased.

(2) Simplicity of operation is increased. Tuning the receiver and reading the bearing are the only operations necessary. Alinement and balancing procedures, although not difficult, must be carefully accomplished by experienced operators or maintenance personnel as appropriate.

(3) Readability is increased. Although its readability on strong signals is not appreciably greater than the aural-null system previously discussed, its readability on moderate and weak signals is considerably greater.

(4) There is equal readability on CW, ICW, and MCW signals.

(5) Readability on swinging signals is increased because the indication continuously and instantaneously changes with the bearing swing, and thus permits the operator to choose the bearing that most likely is correct.

(6) Readability on fading signals is increased because the indicator has a high degree of discrimination between a change in signal level, due to fade, and a change in bearing.

(7) There is increased readability on combinations of swinging, fading, and unfavorably polarized signals, because the indicator exhibits certain features which tell the operator when conditions are most favorable for obtaining a bearing.

(8) Readability in the presence of interfering signals is fair, although not as good as aural indicators. This reverts back to the discrimination by the ear between two signals with only fractional frequency separation. Auto tune systems however, have largely eliminated adjacent channel interference by remotely tuning the DF receiver to within 25 Hz of the target frequency.

3–23. Bearing-Seeking Type Indicators.

a. A bearing-seeking type indicator is used with those DF sets in which the antenna system is automatically rotated by an electric motor to the true bearing position of the source of signal to which the DF receiver is tuned. The bearing indicator in such a system is the component which controls the rotation of the loop driving motor. It causes an indicating pointer to revolve and come to rest when pointing at the azimuth of a signal as read from a circular azimuth scale. The rotation of the antenna is quite often electronic instead of manual. The bearing presentation, however, is still as described above. This type indicator is used primarily in airborne applications and is identified as Automatic Direction Finding (ADF), or automatic radio compass. This information is included to ensure an overall understanding of DF. The ADF provides the pilot with a continuous and automatic indication of the

azimuth to the transmitter. In reality, the automatic radio compass is a left-right, loop-type DF with a servosystem (or electronic system) which automatically (or electronically) turns the loop to its true null.

b. The output of a left-right DF when the loop is off bearing is an audio signal at the loop switching frequency whose amplitude and phase are a function of the loop position with respect to the loop null. In an automatic radio compass, the variations in phase and amplitude of the receiver output voltage cause the loop to be driven by a reversible electric motor (or electronic switching system) to a point of null or zero pickup.

c. The widest application of a bearing-seeking type indicator is in homing type DF for aircraft where size and weight requirements do not permit the use of instantaneous indicators, but where an automatic DF (in the sense that operator/pilot does not have to rotate the antenna to the bearing position and the true bearing is continously indicated) is required.

d. Characteristics of bearing-seeking type indicators are as follows:

(1) It has simplicity of operation comparable to that of instantaneous indicators. The only operational requirement is tuning the receiver to the desired signal and reading the bearing on the indicator.

(2) Readability on strong and moderate CW, ICW, and MCW signals is as good as that of indicators previously discussed.

(3) Readability on weak signals, swinging and fading signals, and on signals in the presence of adjacent channel interference is not comparable to the readability of instantaneous indicators.

(4) Automatic sense indication is coincidental with bearing indication.

Section V

DF RECEIVERS

3–24. DF Receivers.

Any good quality receiver that has excellent sensitivity and selectivity, and can be modified for compatibility with necessary auxiliary equipment, can be used as a DF receiver.

CHAPTER 4

Types of Direction-Finding Efforts

Section I
TERMINOLOGY ASSOCIATED WITH DF EFFORTS

4–1. General.

a. Directwave Direction Finding. Directwave Direction Finding (DWDF) is the term used to identify the DF effort against transmitters located close enough to the DF site that the direct component of the transmitted wave is used to locate the transmitter.

b. Skywave Direction Finding. Skywave Direction Finding (SWDF) is the term used to identify the DF effort against transmitters whose location is far enough away from the DF site that their radio waves have been reflected or refracted by the atmosphere prior to their interception by the DF site.

c. Airborne Radio Direction Finding. Airborne Radio Direction Finding (ARDF) is the term used to identify the DF effort conducted from an airborne platform.

Section II
DIRECTWAVE DIRECTION FINDING

4–2. DWDF Factors.

Radio wave propagation is an extremely important factor in all types of DF. Although a review of wave propagation was given in chapter 2, it is necessary to describe some important differences between wave behavior in the MF/HF frequency range and those in the VHF/UHF range, since these effects have important operational effects on DWDF activities.

a. In the VHF/UHF frequency range (30 MHz and above):

(1) Communications are predominantly short range and line-of-sight.

(2) FM voice is the primary type of transmission.

(3) Transmitters are usually highly mobile, either manpacked or vehicle mounted. They commonly use whip antennas which are nondirectional and vertically polarized.

(4) Transmission is mostly by means of the direct component of the groundwave. Wave travel is primarily in a direct path from the transmitting antenna to the receiving or DF antenna (fig. 4–1).

(5) The directwave component is generally not greatly affected by the ground over which it travels. It is, however, subject to reflection and reradiation by objects above the ground in its wavepath (fig. 4–2).

b. At this point, it is necessary to discuss how reradiation affects the DF effort. Reradiation occurs when the wave front encounters an object composed of any material having high electrical conductivity, is of a size that approximates the wavelength (including fractions or multiples thereof), and has the same polarization. For example, an FM radio transmitting on a frequency of 50 MHz using a quarter-wave vertical whip antenna is located at point A in figure 4–3. The hill mass between the transmitter at A and the DF sets at B and C would ordinarily make it impossible for the transmitter to be heard at the DF sites. A metal fence post approximately 1.5 meters in height is located at point D. As the wave transmitted from the

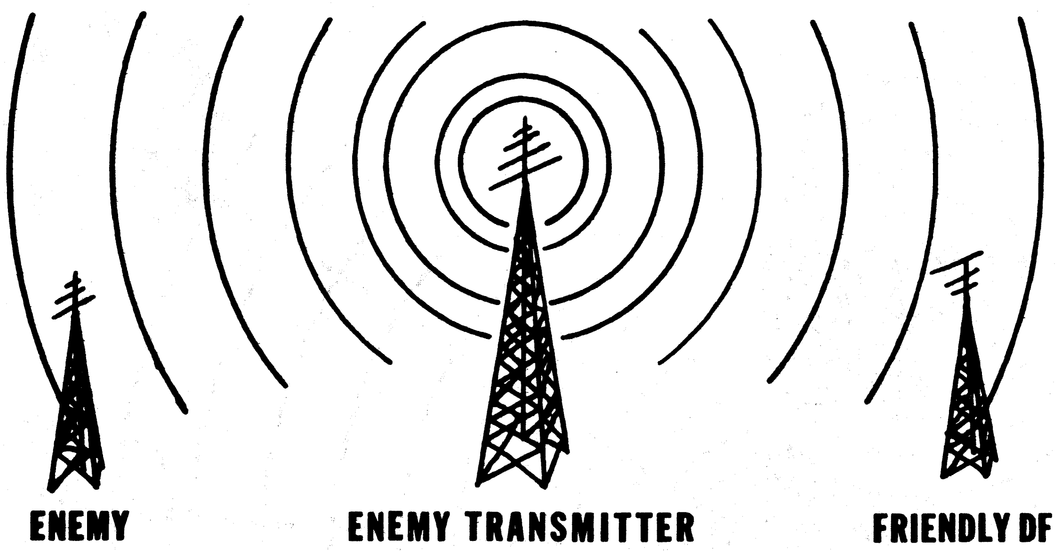


Figure 4–1. Direct wavepath.

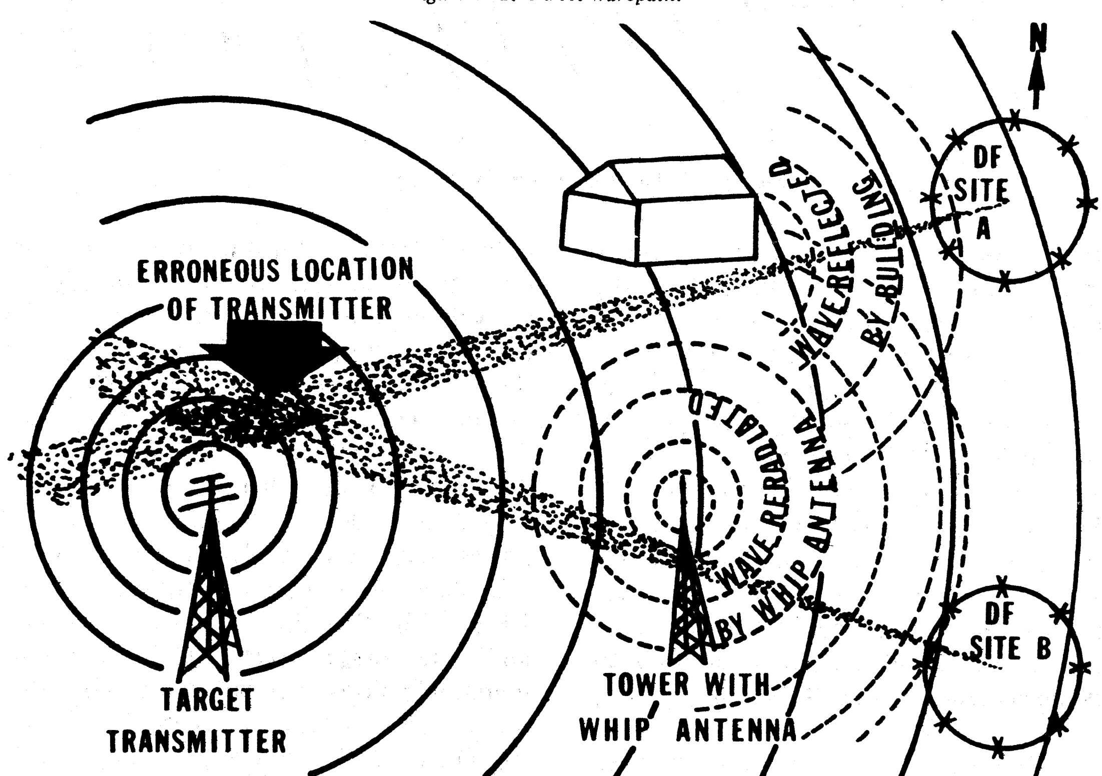


Figure 4–2. Wave reflection and reradiation.

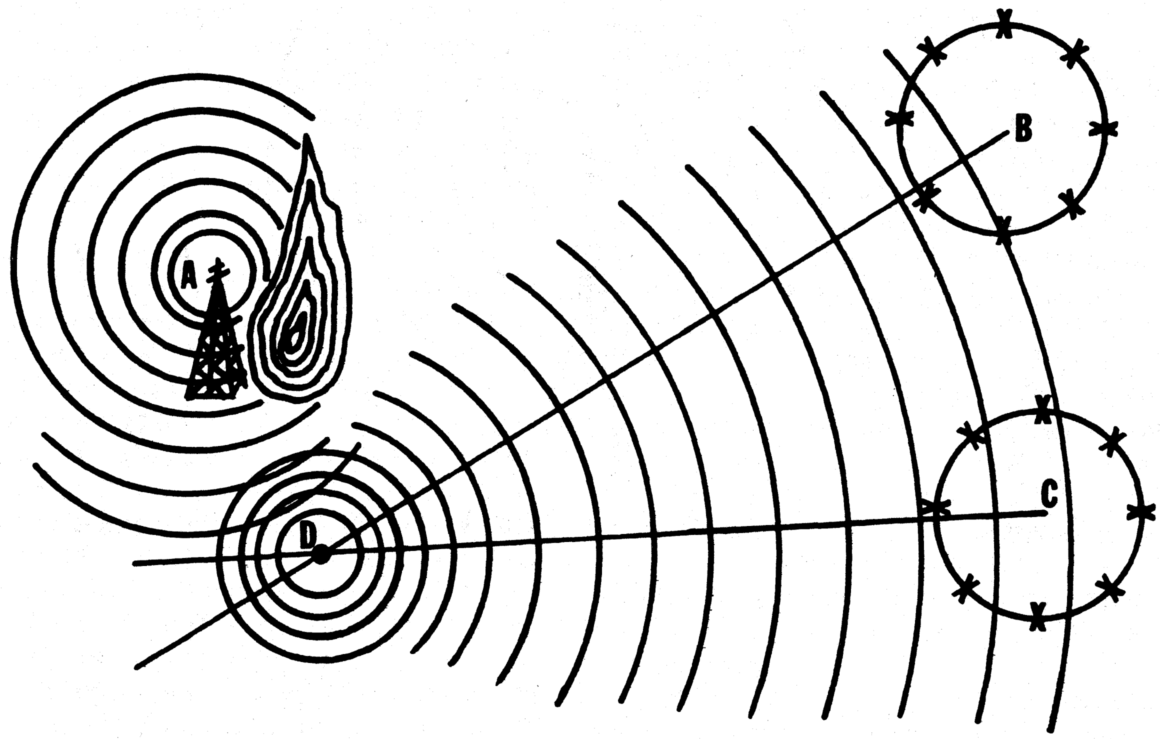


Figure 4–3. Reradiation of transmitted signal.

FM radio passes by the fence post, a small induction field is built up around the post. Since the 1.5 meter post is a quarter-wavelength of the radiated wave, a resonant radiation field is set up causing the wave to be reradiated from the fence post. In this instance, the DF sites will indicate an erroneous location for the transmitter. The reradiated wave is much weaker than the original wave, but when a directwave and a reradiated wave are present at the same time, as shown in figure 4–2, the weaker reradiated wave may still be of sufficient intensity to affect the accuracy of the DF bearing.

c. The discussion pertaining to wave propagation indicates that groundwaves are composed of several components. The waves radiated from a transmitting antenna spread out into the atmosphere and along the earth, as well as into the earth. Because of the conducting properties of the earth, some of the energy is reflected from the earth's surface. The part of the wave not reflected enters the earth where the energy rapidly dissipates as heat. Other portions of the waves spread out along the earth and into the atmosphere and travel to the receiver, providing radio communications, and to the DF set. The field intensity of the groundwave and the range over which groundwave communications can be conducted depends upon many factors (see section III, chapter 2). Most of the received groundwave field intensity can usually be accounted for in terms of one or more of the factors discussed

previously. The resulting groundwave is, therefore, composed of one or more of the following wave components: direct, ground reflected, surface, and tropospheric.

(1) *Directwave.* This component travels directly from the transmitting antenna to the receiving antenna. The directwave is not appreciably affected by the earth's surface, but is subject to refraction in the atmosphere between the transmitter and the receiver. This refraction is particularly important in the UHF range. The directwave is the principal means of transmission in tactical VHF communications circuits, and therefore is of prime importance in DWDF operations above 30 MHz. The directwave (along with the ground-reflected wave) is also the most important wave component in Airborne Radio Direction Finding (ARDF) at all frequencies.

(2) *Ground-reflected wave.* This component reaches the receiver after being reflected off the ground.

(*a*) If both the transmitter and receiver (or DF set) are located on the ground, the difference in path lengths between the direct and the ground-reflected waves is small. These waves arrive almost exactly 180 degrees out of phase, resulting in almost complete cancellation. This is particularly true at frequencies below 30 MHz due to the relatively long wavelengths. The difference in path lengths between the direct and ground-reflected waves would have to be relatively large to compensate for the 180 degree phase shift at the point of reflection. Therefore, in this instance, DF of groundwave communications below 30 MHz are conducted primarily with the surfacewave component.

(*b*) As the height above the ground of the receiver antenna increases, the difference in the path lengths of the two components increases until a point is reached where the difference is equal to the 180 degree phase shift caused by reflection. When the two components are equal in phase, they add together to produce a stronger signal than would be produced by either component alone. At still greater heights, the two waves again arrive out of phase, and cancellation occurs. At extremely high frequencies, many cycles of change from null to maximum occur. At 3,000 MHz, for instance, the nulls are only two degrees apart. In the HF band, there are usually only one or two such cycles because of the greater wavelengths at these frequencies.

(*c*) The height of the transmitting antenna above the ground plays an important part in determining the shape and vertical orientation of the lobes. For instance, if the transmitting antenna is a quarter-wavelength above the ground, the wave goes through a 90 degree phase change in its path from the antenna to the ground directly below, a 180 degree phase change caused by reflection, and a further 90 degree shift on its way back from the ground to the antenna. Thus, the wave front is exactly in phase with the next succeeding wave front emitted from the antenna, and the maximum signal strength is directly above the antenna. These patterns of radiation are very important in ARDF, which operates against a combination of the direct and the ground-reflected wave components.

(*d*) At frequencies above 30 MHz, the wavelengths are shorter and the in-phase condition between the direct and ground-reflected wave components occurs close to the ground. Since the surfacewave component loses strength rapidly at these frequencies above 30 MHz, communications are largely by means of the combined direct and ground-reflected wave components. Reception can be improved by increasing the height of the receiver antenna to increase the path length difference between the direct and ground-reflected wave components to maximize the phase relationship between the two components. Since a full wavelength at 30 MHz is only 10 meters and decreases to 1 meter at 300 MHz, a small adjustment in

antenna height may produce the desired results by trial and error. It should be pointed out that whenever operations are conducted over terrain which inhibits ground reflection, such as areas covered by low brush or rocky desert terrain, the ground-reflected wave may be absent, and communications above 30 MHz will use the directwave component only. In essence, a very low percentage of a VHF signal is adequately reflected to enhance the DF effort.

(3) *Surfacewave.* This component travels directly along the surface of the earth (although it extends above the ground, its strength diminishes with increased height), and is affected primarily by the conductivity and dielectric constant of the ground over which it travels. The surfacewave is the primary component acted upon by ground-based DWDF systems below 30 MHz. The three most important factors of this type wave propagation are:

(*a*) *Frequency.* The lower the frequency, and therefore, the longer the wavelength, the greater the range. The LF and VLF frequency bands are used for extremely long-range communications These frequencies are commonly used as navigational aids for ships. The MF range, which includes the standard broadcast band, can support moderate-range communications when the transmitting equipment is specially designed for groundwave propagation. Over sea water, this frequency range can be used for distances up to approximately 5,000 kilometers. In the HF band, wavelengths become shorter, and the dielectric constant and conductivity of the ground become the most important factors in surfacewave propagation. Regardless of ground conductivity, however, as the frequency increases, the groundwave range decreases. In the vicinity of 20 MHz, the groundwave loses strength very rapidly, and above 30 MHz, it is virtually nonexistent for purposes of practical communications and DF. Most military communications below 30 MHz operate in the 2–20 MHz range (predominantly in the 1.5–8 MHz band) and rely mainly on skywave propagation. Groundbased DWDF systems working against such transmitters are actually receiving groundwaves which are unintentional byproducts of transmissions whose main energy is directed towards the ionosphere rather than along the surface of the earth (fig. 4–4.)

(*b*) *Terrain.* The electrical characteristics of the ground over which the groundwave component travels can affect its range considerably. Sea water is the best conductor, having a conductivity factor approximately 5,000 times as great as dry soil.

(*c*) *Polarization.* When the surfacewave is horizontally polarized, the earth has a short-circuiting effect which causes the wave to dissipate rapidly into the ground. For this reason, surfacewaves are generally vertically polarized. If a transmitted wave has some degree of both vertical and horizontal polarization, the horizontal portion will be quickly absorbed and only the vertically polarized part of the wave will travel any appreciable distance. Because of this, surfacewaves can be considered to be vertically polarized. This is an important point, since most DWDF systems employed against surfacewaves use vertical loop or monopole antennas which are designed to receive vertically polarized waves.

(4) *Tropospheric waves.* See paragraphs **2–14** and **2–15.**

d. In the MF/HF range, the enemy transmitters against which DWDF is being conducted are likely to be communicating with another station hundreds of kilometers away by the skywave mode of transmission. The groundwave received by the DWDF team is generally an unintentional byproduct of a skywave transmission (fig. 4–4).

(1) This wave travels along the surface of the earth and can be strongly affected by the earth and natural or manmade objects on its surface. Obstructions between the transmitting antenna and a DF site can

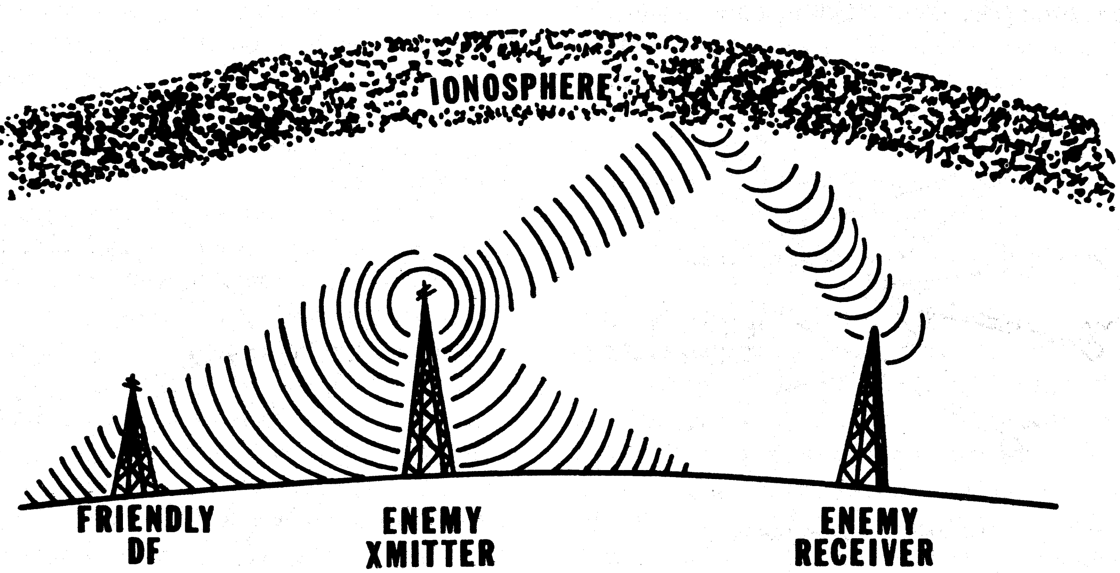


Figure 4–4. Groundwave DF.

cause the wave to deviate from a straight-line path and introduce wavepath errors of varying degrees.

(2) The distance these groundwaves can be received by a DWDF set is subject to extreme variations and is affected by such factors as transmitter power output, antenna type, terrain, manmade objects, and operating frequency. Advance estimates of expected groundwave range in a given environment can be made if some knowledge of the enemy's communications equipment and operating techniques is available; however, some actual operating experience in each situation is usually required before reliable range estimates can be made.

4–3. The Baseline and Baseline Distance.

The establishment of a suitable baseline is affected by tactical, strategic, and technical considerations. A direction-finding baseline is identified as the imaginary line or axis along which the DF equipment of a DF network is deployed. Essentially, there are two types of baseline configurations utilized for deployment of a DF network; concave or straight, and convex. The baseline distance is that straight line distance that separates the two outermost DF stations or sites. As a rule of thumb, a DF network fix capability is equal to the distance of the baseline measured from the center of the imaginary line joining the two outermost DF sites. For example, if the DF baseline is 80 km in length, the net location capability is 80 km in depth. Tactically, the deployment and movement plans of the friendly unit in whose area of operations the DWDF net is established will determine which areas are available for the siting of the DF equipment. However, the target area to be covered, depending upon a technically acceptable environment, will dicatate the baseline configuration that is employed in any given situation.

a. Concave. If it is expected that the target locations will be in a rather compact, narrow but deep, frontal area, it is best to locate the direction finders on a concave or

even straight base line (fig 4–5). With this baseline, the azimuth angles are satisfactory at longer ranges and excellent at short ranges.

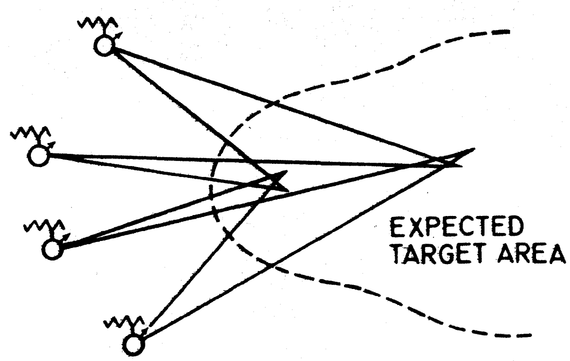


Figure 4–5. Concave baseline.

b. Convex. If target locations are anticipated to be located over a wide flanking, short-in-depth area, a triangular or convex (quadrilateral) baseline is suitable (fig 4–6). Using a convex baseline in this situation provides a reasonable azimuth angle over a wide front. It is probable that the convex baseline will satisfy the average situation.

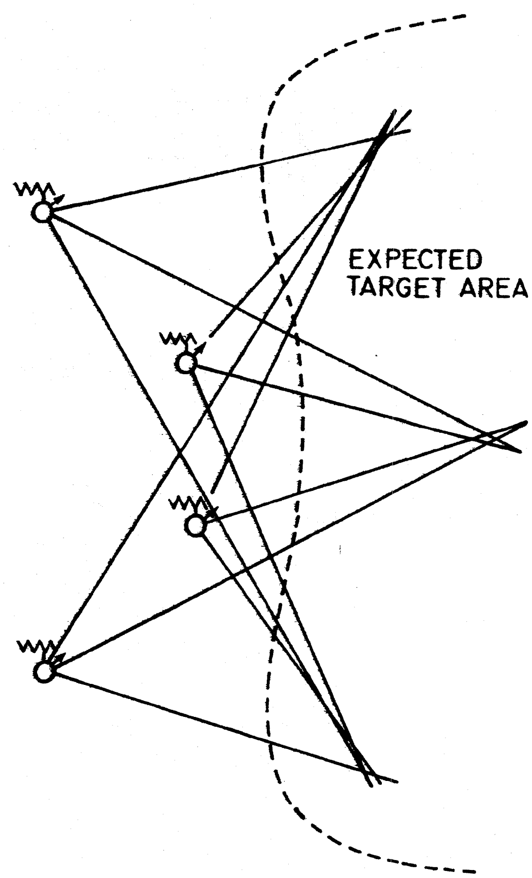


Figure 4–6. Convex baseline.

4–4. Baseline Considerations.

The physical security of the DF site presents a combination of technical and tactical problems. Sites that are most suitable from a technical standpoint may be tactically undesirable, and vice versa. In many cases, a technically desirable site may be located in a risky area, and a suitable defensive perimeter must be established. If barbed wire is required in the vicinity of the DF site, or if armored vehicles are stationed near the DF antenna, these metallic objects will introduce DF errors that may completely negate the site's original technical advantages. DWDF equipment is subject to serious errors caused by poor siting. Siting criteria, which are applicable to all DF efforts, will be discussed in detail in a later paragraph of this chapter. While it is difficult to locate a technically ideal site, it is essential that the siting criteria which follows be adhered to as closely as possible.

4–5. Terrain Considerations for Wavepath.

The terrain on which both the DF sets and the target area are located is an important factor in DWDF operations. In favorable terrain, such as flat areas with few obstructions, all of the DF sites may have a clear electronic "view" of the target area. The establishment of the baseline is largely a matter of placing the DF sets so that good bearing angles for triangulation within the

target area are possible. Ideally, each of the sites should have an unobstructed wavepath between the DF antenna and any point within the target area. In most cases, however, this is not possible. Sites should be arranged so that portions of the target area that are "masked" to one or more sites can still be covered by at least three other sites. This is similar to setting up interlocking fields of fire for weapons, except that in the case of DF sets, each area must be covered by three "lines of fire" instead of one or two (fig. 4–7).

4–6. Masking of Transmitters by the Enemy. There are some situations in which the enemy can take advantage of terrain features to mask his communications from friendly groundbased DF sets. Such a situation is illustrated in figure 4–8. The transmitting antenna, being hidden behind a hill is electronically masked from the DF sites, yet is able to communicate effectively with his outstation. Although this type masking is most effective in line-of-sight communications, the possibility must be considered whenever the terrain features in the enemy's area of operations afford the opportunity.

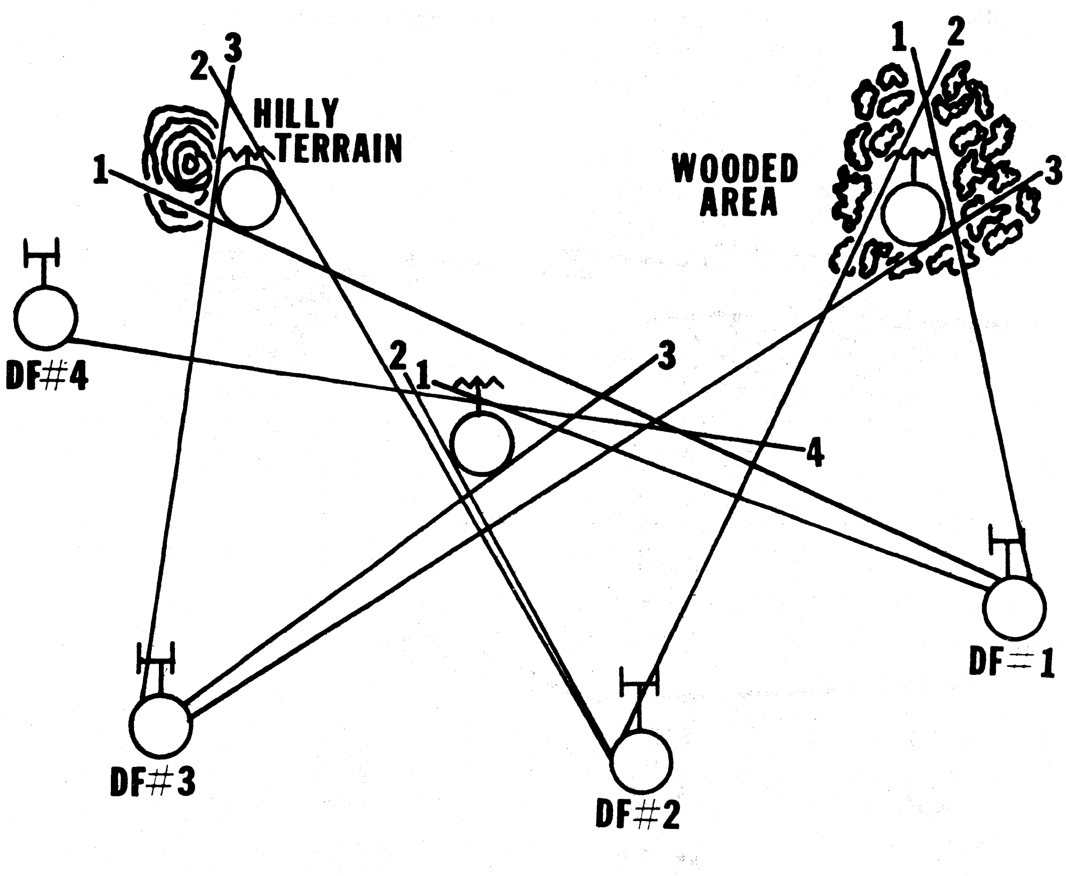


Figure 4–7. DWDF net with curving baseline.

4–7. Limitations of Baseline Establishment.

In some situations, conditions may be prohibitively unfavorable for DWDF operations because of impossible terrain conditions, unusual propagation factors, or baseline restraints. An example of a prohibitive baseline limitation is an amphibious operation with an assault on a very narrow beachhead. In this case, the area under friendly control is too small to establish an effective baseline, therefore, effective DF cannot be employed. In such a situation, it would be necessary to rely on ARDF support until the beachhead is expanded to accomodate a suitable baseline.

4–8. Map Reconnaissance for Establishing DWDF Nets.

The most important step in setting up the DWDF net is thorough planning of the operation. Maps of the area must be carefully studied to find favorable site locations that present the best possible wavepaths from the target areas. The size and shape of the deployment area must be considered, as well as the estimated transmission range of enemy transmitters. The number of DF sets available for deployment will heavily influence the planning estimates. Sites must be in good radio reception areas and as far removed as possible from all obstructions, particularly metallic objects. Even under particularly unfavorable conditions, acceptable DWDF results can be obtained if the operation is carefully planned, with proper attention paid to the fundamentals of DF site selection and wavepath considerations.

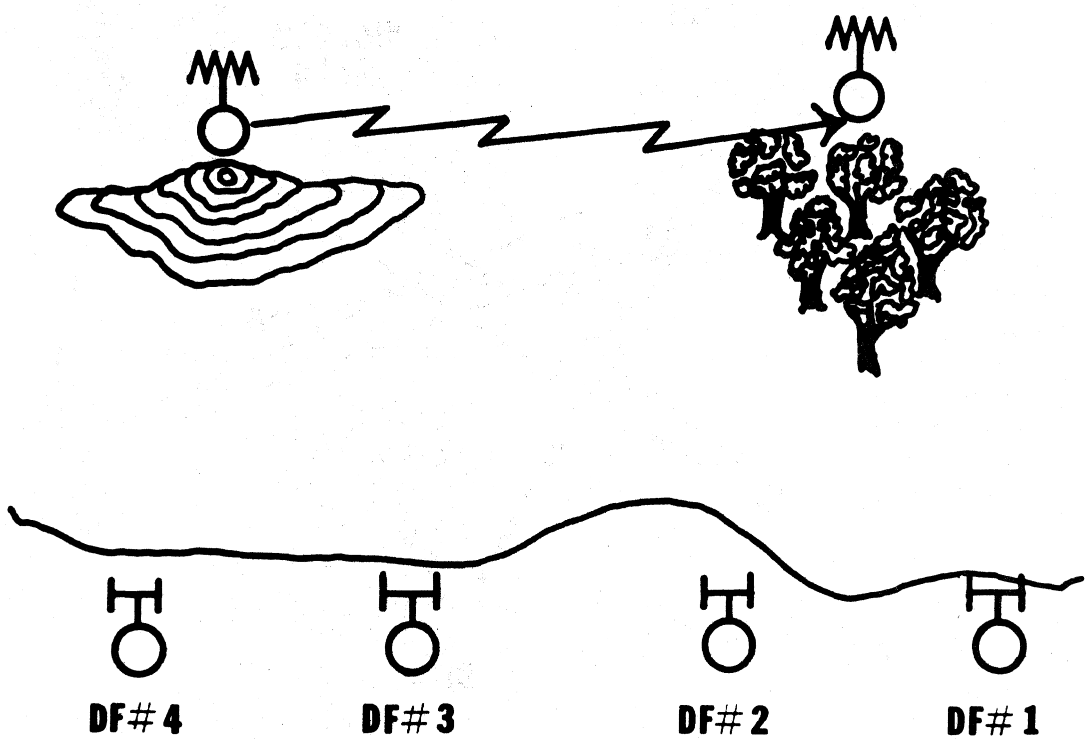


Figure 4–8. Enemy transmitter masked to friendly DF stations.

Section III
SKYWAVE DIRECTION FINDING

4–9. SWDF Factors.

This discussion of SWDF will deal only with the acquiring of bearings from skywaves arriving at DF antennas. The tactical and technical requirements discussed in paragraph **4–2** for DWDF site selection will also apply to most SWDF sites except where friendly DF sites are installed in CONUS or countries friendly to the United States and where physical security would not be a major requirement. DF sites which deal primarily with SWDF are quite often designed to provide strategic coverage over vast geographical areas, such as an entire continent. Nets of this nature will frequently have sites scattered along a baseline thousands of kilometers in length.

4–10. The Baseline.

Site acquisition for strategic DF nets in foreign countries will usually be a joint effort with the host country. The DF planner gives the site requirements to a consular office or an embassy which negotiates with the host country for the site. For those installations to be equipped with large CDAA, approximately 40 acres will be needed at each site. For smaller equipment sites, the baseline will usually remain in land areas where tactical superiority is exercised by friendly forces. Siting criteria, discussed in paragraphs **4–2** through **4–6**, apply to SWDF as well as to DWDF.

Section IV
AIRBORNE RADIO DIRECTION FINDING

4–11. General.

In the ARDF effort, the aircraft is actually the DF site, consisting of a combination of dipole antennas, a coupling system, receivers, integrated equipment that will resolve the ambiguity of the incoming RF signal, and air-to-ground communications equipment.

4–12. Concept of Employment.

Within TOE limitations, aviation companies with the ARDF capability are deployed so their product is available to all combat echelons. Tasking is done through a central control section at the supported command level. These ARDF aircraft are used to supplement groundbased collection systems by providing an airborne DF platform to extend the radio horizon. The mission of ARDF involves acquisition and location of targets within the supported commander's area of interest.

4–13. Aircraft.

Normally, the aircraft deployed for tactical ARDF missions is of a standard type modified to accommodate ARDF equipment.

4–14. Equipment Employed in ARDF Operations.

In addition to the normal complement of installed antennas, the ARDF aircraft will have some combination of the following antennas: two wing-mounted dipole antennas, two inboard nacelle dipole antennas, two horizontal stabilizer dipole antennas, one fuselage-mounted spaced-loop antenna, and a whip antenna used to search for targets. Some will also have a fuselage-installed antenna group for use with the radar navigational system. Other equipment necessary for ARDF is:

a. Direction-finding receiver.

b. C–11 gyroscopic compass system.

c. C–12 gyroscopic compass system.

d. Radio Magnetic Indicator (RMI).

e. Inertial naviation system.

4–15. Crew Requirements.

The crew for a normal mission on an ARDF aircraft would consist of a pilot, a copilot, and one or more operators depending upon equipment on board.

4–16. Mission Configuration.

ARDF aircraft are configured with equipment to cover various frequency ranges. The aircraft configuration used would depend upon the supported commander's intelligence needs.

4–17. Navigational Requirements in ARDF Operations.

The pilot is responsible for the safety of his aircraft and accomplishment of the mission. To partially satisfy this requirement, he must know where he is at all times. For routine flying, arrival within one quarter of a mile of the destination is sufficiently accurate. He can adjust any minor navigational inaccuracies in the traffic pattern at his destination. Unless suitable adjustments for aircraft location are made, this criterion is intolerable in ARDF operations. The pilot must always know the precise location of his aircraft over the ground using dead reckoning and referring to visible landmarks on the ground and on his charts. New aircraft have instruments that operate in conjunction with satellites and ground stations which keep the pilot informed of his precise location.

4–18. General Operating Environment of ARDF Units.

Each aviation unit requires a base of operations from which the aircraft can fly. The aviation unit providing ARDF support requires an adequate operations area and a secure communications facility through which mission assignments can be received and results reported.

4–19. Flight Considerations for ARDF Operations.

Before the mission flight, the aircrew is given a thorough briefing of the target area. The current artillery advisory, in the mission area and enroute, is carefully studied because the ARDF aircraft operate at altitudes low enough to be vulnerable to high trajectory firing. The pilot then decides whether to fly a direct route or make some detour to avoid artillery and hazardous terrain. The pilot notes any emergency landing areas close to the intended route and studies the terrain features on the chart for suitable basepoints, such as distinctive patterns of railroad tracks or roads, sharp bends in rivers or trails, quarries, small lakes, and other easily identifiable terrain features.

4–20. Integration of Results.

Tasking, plotting, and reporting is generally handled within the channels that regularly process DWDF and SWDF reports. ARDF results on high priority targets in which a tactical unit has pressing and immediate interest may be passed directly to the supported commander by secure means. Although passed directly, the results will still be processed with the results from other DF efforts through a central control or plotting facility. ARDF contributes to the overall effort in much the same manner as the other efforts previously discussed.

CHAPTER 5

Direction-Finding Techniques

Section I

MAPS

5–1. Use of Map Projections with DF.

The basic method of DF plotting consists in the measurement, at a receiving or centralized plotting station, of the angle between the direction of a predetermined reference line (usually magnetic or true north) and the direction from which the electromagnetic waves arrived from a distant transmitting station. The results are plotted and evaluated on a map. For this reason, the more important types of map projections are explained below.

5–2. General.

a. Definition. A map as used for DF plotting, is a graphic representation of a portion of the earth's surface. Although drawn to scale, no map is absolutely accurate since it represents the earth as a plane or flat surface. Accuracy depends upon the method used in making the map, and certain properties must be sacrificed to obtain other desirable features in accordance with its specific use.

b. Introduction. No portion of the earth's surface can be spread out into a flat plane without some "stretching" or "tearing." This is illustrated by attempting to flatten either the cap of an orange peel or a portion of a hollow rubber ball. The outer portion must be stretched or torn before the central part will flatten. However, there are some surfaces which can be spread out in a flat surface without stretching or tearing; these are called developable surfaces. Those surfaces which cannot be spread out in a flat surface, such as a sphere, are called nondevelopable surfaces. Two well-known developable surfaces are the cone and the cylinder. If a paper cone is cut from the base to the apex, the conical surface can be spread out in a flat surface without tearing or stretching (Capital A, fig. 5–1). If such a cone is flattened, any line or curve drawn on it will have exactly the same length as before. In the same manner, if a cylindrical surface is cut from base to base, the whole surface can be rolled out into a plane or a rectangle (Capital B, fig. 5–1). In this case there is no stretching or tearing of any part of its surface.

5–3. Reference Points on a Spheroid.

On a spheroid such as the earth, it is necessary to have some points or lines of reference so

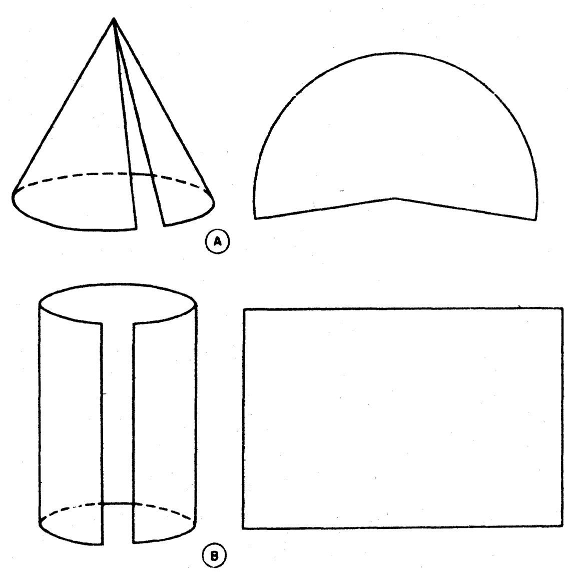


Figure 5–1. Cone and cylinder, developable surfaces.

that any point may be located with respect to them. Places on the earth are located by latitude and longitude, which form a network of lines running true east and west (parallels of latitude) and true north and south (meridians of longitude).

a. Derivation of Reference Points on a Spheroid. The ends of the earth's rotational axis are called the North Pole and the South Pole. With these as starting points, assume the earth is divided into two equal parts by a plane perpendicular to the axis midway between the poles. The circle formed by the intersection of this plane and the surface of the earth is the equator and divides the earth into the Northern Hemisphere and the Southern Hemisphere. Any circle upon the earth which divides it into two equal parts, such as the equator, is called a great circle (see fig. 5–2). It is customary in the United States to divide these great circles into 360 equal parts called degrees.

(1) *Meridians.* As shown in figure 5–3, any number of great circles can be drawn through the two poles, and each will cut the equator into two equal parts. Each circle may be divided into 360 degrees, with the equator 90 degrees from either pole. These great circles are called meridians.

(2) *Establishing meridians of longitude.* To further reference a point, it is necessary to number the meridians east and west from an established location. Most countries have adopted the meridian passing through the Greenwich Observatory in England as the zero meridian, or the prime meridian (0 degrees). The degrees of longitude are counted from 0 to 180 degrees east and west (fig. 5–4). The great circle that passes through the poles and Greenwich, England, is called the prime meridian on one side of the globe, and the 180th meridian on the other side, since at this point it is both 180 degrees east and west of the prime meridian. Thus, east-west reference points are provided.

(3) *Establishing parallels of latitude.*

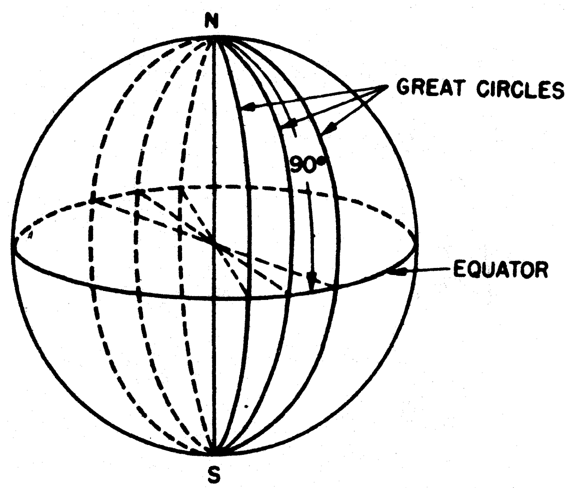


Figure 5–2. Great circles.

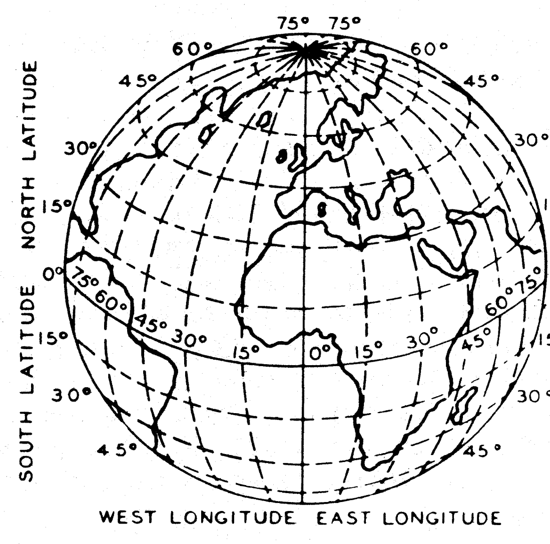


Figure 5–3. Projection of a sphere showing the arrangement of longitudes and latitudes.

Assume that on one of these meridians a point is taken 70 degrees north of the equator, and a plane is passed through this point perpendicular to the north-south axis

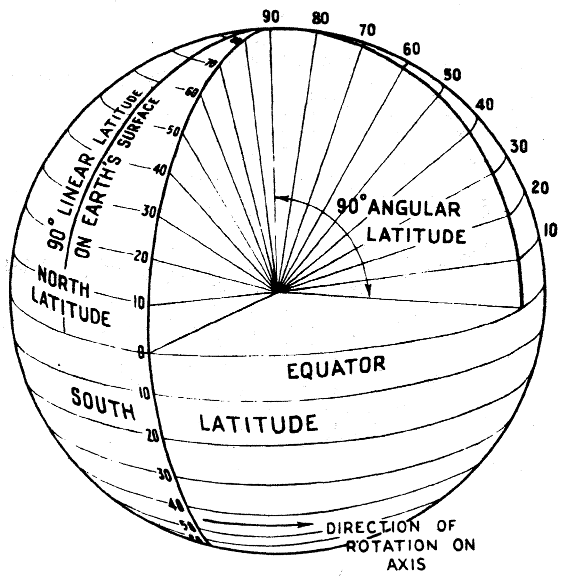


Figure 5–4. Diagram of the globe indicating the derivation of longitude.

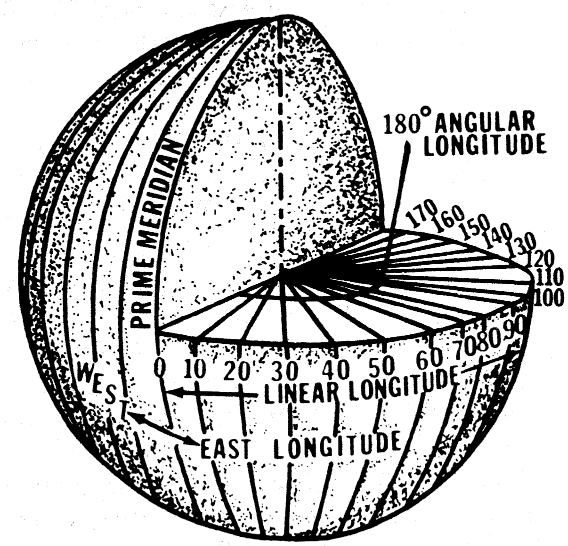


Figure 5–5. Diagram of the globe indicating the derivation of latitude.

(parallel to the plane of the equator). The intersection of this plane and the surface of the earth will form a small circle called a parallel of latitude (fig. 5–5). Every point on this circle will have a latitude of 70 degrees north. Other such circles can be formed at 20 degrees, 40 degrees, etc. Thus, since the equator was drawn as a great circle midway between the poles, a point north or south with reference to the poles can be located.

b. Initial Problem of Map Projection. A sphere constructed with meridians and parallels on it represents the earth with its imaginary meridians and parallels. As previously stated, a sphere is nondevelopable. Therefore, the problem of map projection is one involving a systematic drawing of lines representing meridians and parallels on a flat surface, either for the whole earth or any desired portion.

5–4. Selecting a Type of Map Projection.

The spheroidal shape of the earth cannot be represented on a plane without distortion, therefore, a compromise of desirable properties to obtain the most practical features for a specific use must be made. Many different types of map projections have been devised, each having special merits for their intended use, while compromising other features. The map projections used for DF plotting must be of a type that a straight line from a given point will indicate the true azimuth. Three map projections commonly used for DF plotting are:

a. Universal Transverse Mercator Projection. The Universal Transverse Mercator (UTM) system (fig. 5–6) is the most commonly used map projection method for military purposes. It can be easily oriented for combat situations and readily used with a compass to find a true azimuth from any given point on the map. This system, makes it possible to plot from point to point using a

straight line called a rhumb line. This rhumb line may be used to determine latitude and longitude of any point along its path, up to 300 kilometers. This is of great importance because it is only through use of a map projection system of this type that a flat presentation of a globular object may be displayed with the distortion minimized.

b. Gnomonic Projections.

(1) The gnomonic projection is the most commonly used map projection system for long range DF plotting. It is particularly useful when plotting across great expanses of ocean.

(2) A gnomonic projection of the earth is derived by projecting the surface of the globe, from its center, upon a planar surface. This projection method represents all great circles as straight lines, and is the projection's chief merit. This property is important in DF, because the shortest route between two points (a straight line) is always a portion of the arc of a great circle. Radio waves travel more or less on great circle routes.

(3) The mathematical limit of this projection is a hemisphere. The practical limit is a quarter of the globe (90 degrees) since the distortion beyond that point becomes severe.

c. Equatorial Projection. This projection was rarely used in earlier DF efforts. However, with the installation of large fixed sites with DF multiband capabilities, this projection is essential for maximum accuracy and convenience. With the development of computer technology, the computer produces such projections from any given reference point. This projection has a relatively small scale error if it is not extended beyond a hemisphere. It is possible to show the whole earth, although distortion increases rapidly toward the perimeter. Figure 5–7 is a map representation of this projection centered on New York.

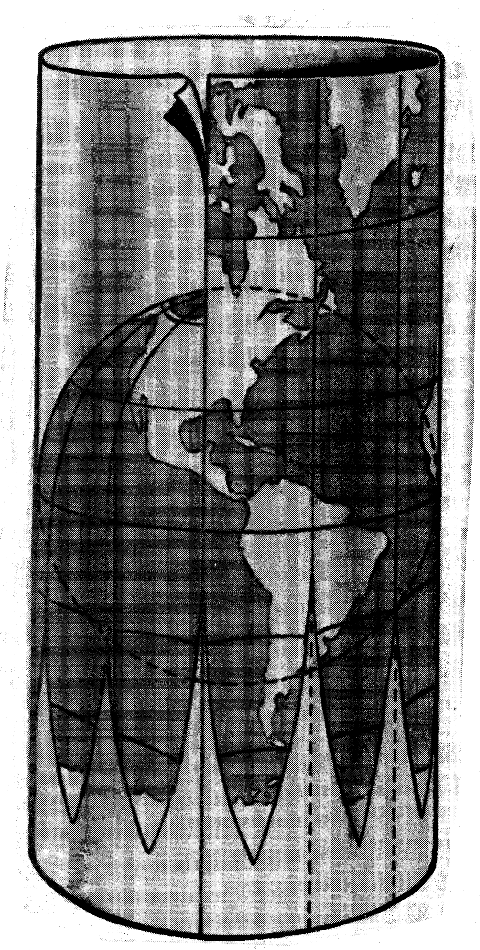


Figure 5–6. Mercator projection on a cylinder indicating method and showing polar distortion.

5–5. Aeronautical Charts.

Another type of map encountered in the plotting of DF results is the aeronautical chart. The major difference between aeronautical charts and standard Army maps is that the grid lines in aeronautical charts are straight and are oriented to true north, and the particular areas in which magnetic variation occurs are indicated by broken magenta-colored lines which follow the exact electrical variations in the earth's surface. These lines, called isogonic lines, waver and

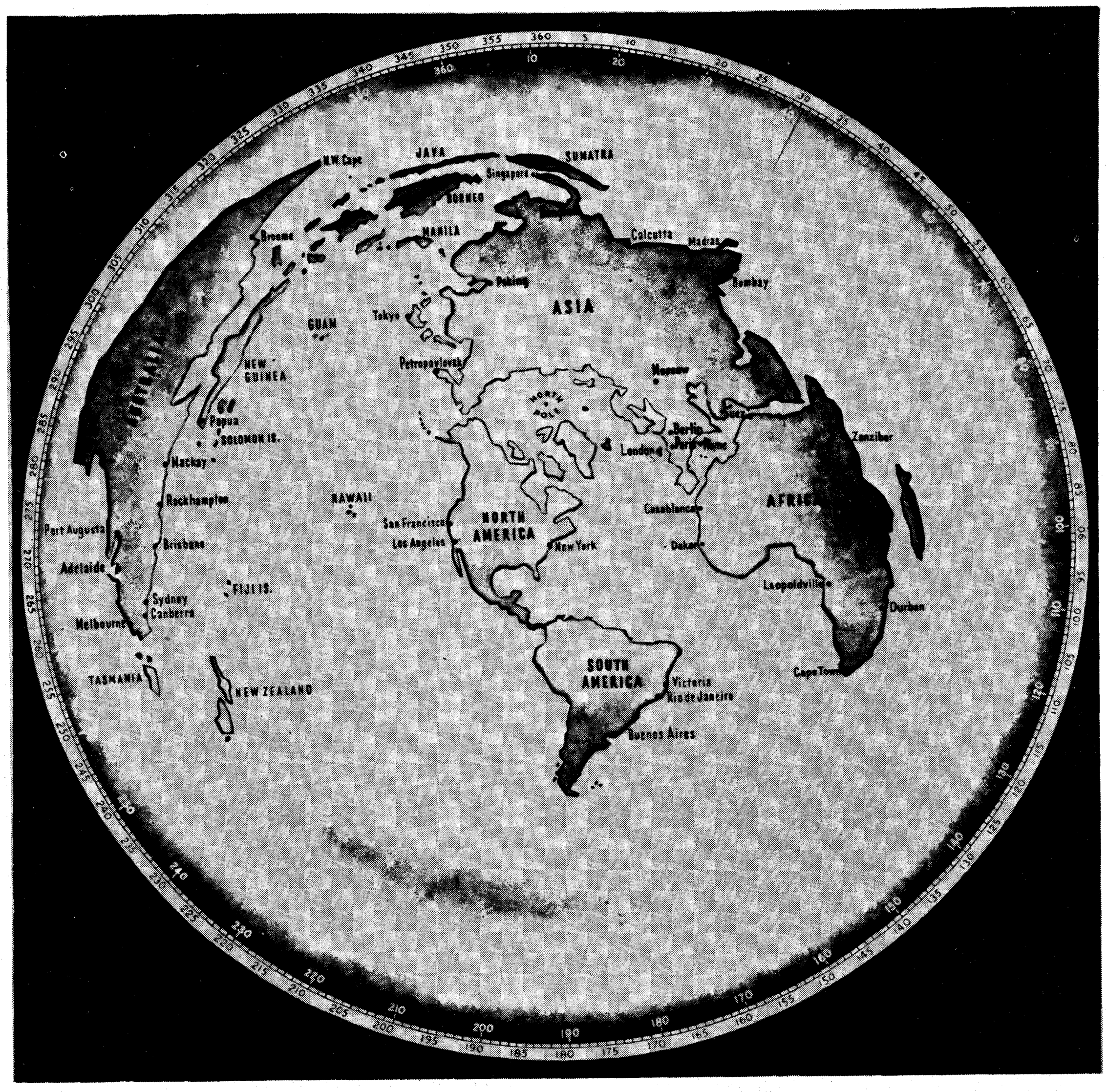


Figure 5–7. Azimuthal equidistant projection centered on New York.

slant to follow the electrical fields which they designate. Where true north and magnetic north are almost identical, these lines are called agonic lines, and there would be no deflection of the compass needle from true north indicated by the grid lines. As electrical fields in and around the earth do not respect the orderly requirements of the map makers for maximum accuracy, the user must "average" the variation depending upon the distance he may be from an isogonic line.

5–6. Magnetic Variation and Use of the Compass Rose.

Magnetic north and true north do not coincide. True north and south (the poles) are used as the chart poles because they are fixed

and unvarying. Magnetic north is some 650 kilometers south of geographic north, and is constantly changing its exact location.

a. Variation. When a compass needle points north, it is not pointing to the north of the chart (true north), but rather to magnetic north. The amount of separation between these two points is called variation, and is expressed in degrees. The amount of variation differs with the locality, since it follows the magnetic channels between the poles. It may vary east or west of the true meridian, or it may not vary at all (fig. 5–8). This variation is a continually changing phenomenon which could not be represented on any map or chart perpetually. Therefore, maps should be obtained with the latest variations posted before planning any DF plotting effort.

b. Use of the Compass Rose. The amount of variation for each locality on charts and maps is indicated by either a compass rose, a declination diagram, or a narrative statement, depending upon the age and type of map. A compass rose is a double graduated circle, the outer one marked in degrees and the inner one marked in compass points. Figure 5–9 illustrates the compass rose on a 1939 map. The outer circle, which is stationary, is oriented to true north. Its zero degree is true north. The inner circle is oriented to magnetic north for the year indicated in the center of the compass rose diagram. The difference between the two points is the variation in the year indicated in the center.

(1) The variation since the year the chart was published is obtained by multiplying the annual increase or decrease, indicated in the lower half of the center of the rose, by the number of years elapsed between printing and reading. Therefore, in figure 5–9, the variation in the year 1939 was

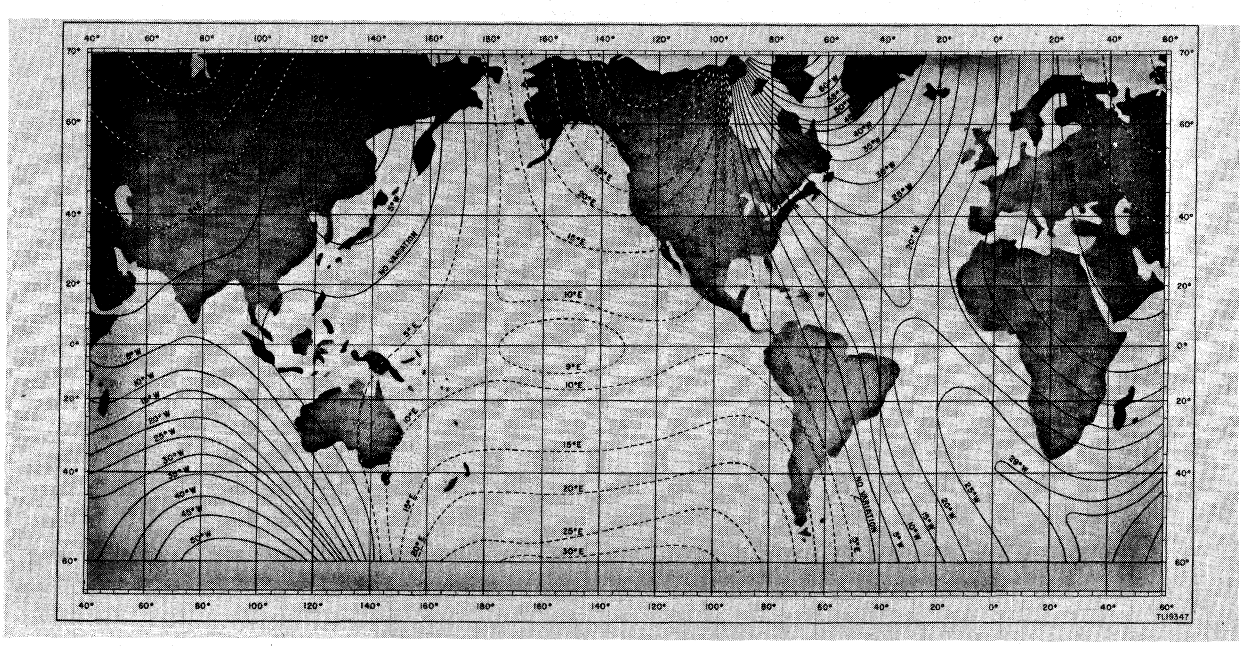


Figure 5–8. Map of the world showing typical zones of magnetic variation.

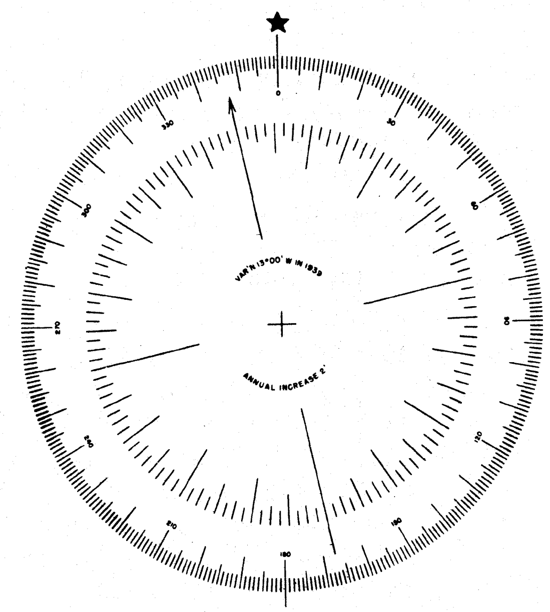


Figure 5–9. Compass rose.

13 degrees 00 minutes W and the variation increased 2 minutes each year, as indicated in the center of the rose. Therefore, the variation in 1946 would equal 7 (number of years between 1939 and 1946) times 2, or a total variation of 13 degrees 14 minutes W. If the variation had indicated an annual decrease, the amount would be subtracted from the 1939 variation.

(2) When a true direction reading from a map is changed to a magnetic direction, easterly variation is subtracted from the true course indicated, and westerly variation is added. A memory aid, in the form of a simple rhyme is, "East is least (subtract) but west is best (add)." The reverse is true when changing from a magnetic to a true course reading.

(3) The compass rose variation indicator is not used on many maps today. An explanation is included for its use since there are many parts of the world that remain uncharted or inaccurately charted, and older maps may be the only references available.

5–7. Declination Diagrams.

a. A declination diagram is placed on most large-scale maps to enable the user to orient the map properly. The diagram shows the interrelationship of magnetic north, grid north, and true north. On medium-scale maps, declination information is shown by a note in the map margin.

b. Declination is the angular difference between true north and either magnetic or grid north. There are two declinations, magnetic and grid. Magnetic north, grid north, and true north (fig. 5–10) are indicated on the diagram by a half arrow, straight line, and star respectively. Since it is not the intent of this manual to discuss basic map reading, FM 21–26, Map Reading, should be used as a basic reference.

Section II
DF SITE REQUIREMENTS

5–8. General.

Whenever a DF site is set up in a new location, its antennas must be precisely oriented to a known reference point to produce an accurate measurement of the arrival angle of a wave front. Without this accuracy, the plotting of reported bearings would be valueless. DF stations of the US Army have their antennas oriented to true north. To establish a true north reference line on the map of the area in which the DF site is being erected, it is common to use celestial bodies and satellites for maximum accuracy. Alternatively, field expedient methods may be used. Chapter 5, FM 21–26 explains in detail those field expedients which may be used to determine the direction of true north.

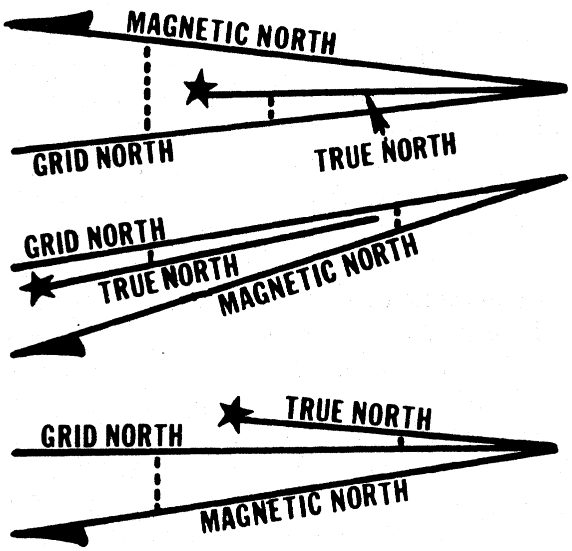


Figure 5–10. Declination diagrams.

5–9. Siting Errors.

Siting, as well as orientation, of DF antennas is extremely important in obtaining maximum DF accuracy. Since radio waves can be deflected from their paths by various obstacles, and DF equipment can only measure the angle of arrival where the DF antennas are located, the DF set should be positioned where the wavepath is least susceptible to outside influences. Then the DF set will give the most accurate representation of the true direction of wave travel. Obstructions in the near vicinity of the site are particularly objectionable; the closer the obstruction is to the DF site, the greater its adverse effect on the site. DF errors caused by obstructions in the vicinity of the DF site are known as site errors. Figure 4–2 illustrates site errors caused by reflecting or radiating objects located near the DF site.

5–10. Site Criteria.

a. The area should be substantially flat for approximately 90 meters from the DF ante[illegible] and have no more than a gentle slope fo[illegible]al times that distance.

b. The area should be the highest level area in the vicinity. A site in a valley is usually unsatisfactory.

c. Mountainous or hilly country should be avoided.

d. The area should be as far as possible from the shore line of large bodies of water (at least 5 wavelengths of the lowest frequency to be measured). If the installation must be made on or near the coast, the flattest area should be selected and the DF antenna should be oriented so that the azimuth arc to be measured is as nearly perpendicular to the coast as possible.

e. The earth at or around the site should have uniformly high conductivity and moisture content. Areas uniformly covered with grass or vegetation usually meet this requirement. Rock or sandy soil is poor as a DF site. Areas having low conductivity are preferable, however, to areas having high conductivity spotted with rock formations, sand, or a varying moisture content.

f. Regions where there are abrupt discontinuities of the earth should be avoided. Sharp changes in terrain elevation usually indicate the presence of rock or mineral outcroppings, or underground streams.

g. The site should be removed from tall trees, buildings, wire fences, power or telephone lines, radio antennas, railroad tracks, buried metal conductors (cables and pipelines), sharp ground contour changes (mountains, cliffs, and ravines), chimney stacks, water towers, rivers, lakes, and streams.

h. Distances to be maintained between the DF site and these obstructions to minimize their effect on accuracy are listed in table 5–1.

Table 5–1. Preferred Distance from Obstacles.

OBSTACLES	*DISTANCE TO BE MAINTAINED*
Scattered trees and single small buildings	185 meters
Wire fences	275 meters
High cliffs and deep ravines	1.6 kilometers or farther
Buried metallic conductors	275 meters
Chimney stacks and water towers	450 meters
Railroad tracks and overhead conductors (utility lines and antennas)	450 meters
Mountains	10 to 50 kilometers
Rivers, streams, and lakes	550 meters

5–11. Comparison of DWDF and SWDF Site Establishment.

In establishing large, fixed-installation DF sites, all of the technical considerations can usually be met. Tactical DF sites, however, present more of a problem since the areas available for sites are fewer, and such factors as physical security and logistical support become predominant considerations. Once a site has been installed, it is necessary to ensure that it remains free of obstructions. A restricted zone should be established for a distance of 150 to 300 meters in all directions from the center of the DF antenna array. This zone must be kept free of all construction and material storage. As a minimum, this area must be kept completely free of metallic buildings, vehicle parks, and other obstructions listed in the above table.

5–12. Site Testing.

In addition to the physical criteria specified previously, additional tests should be made on the DF site if time and the tactical situation permit.

a. Electrical Inspection.

(1) *Noise measurement.* Measure the noise level with a field strength meter or comparable equipment, at the major frequencies on which the DF set will be operated. If the equipment is to be used over a band of frequencies, measurements should be made throughout the band. For a suitable DF site, the noise level (other than temporary atmospheric noise) should be low, otherwise many signals of interest will be lost.

(2) *Field pattern.* This test is made to determine uniformity of reception for the DF site. An explanation of this test was detailed in paragraph **3–1***a*. Although the directivity of an installed antenna was discussed in the polar diagram section, the reader can compare the discussion with figure 5–11 and reasonably deduce how the test for uniform reception of the chosen site is made with the target transmitter and field strength meter instead of a receiver. The field strength measurements for each position of the target transmitter (as indicated in fig. 5–11) must be taken with all measurements marked accurately. Each frequency must be plotted on rectangular coordinate paper relating field strength to azimuth, and the resulting graph should be substantially a straight line. Any irregularities indicate an absorption or reflection of the wave which would affect the accuracy of the DF. If the variations exceed 25 percent of the average field strength, especially in azimuth arcs where maximum accuracy is desired, the site is unsuitable for DF. If the visual and electrical inspection discloses no objection to the use of the site, the DF antennas may be erected.

b. Tactical Requirements for Good Sites. In addition to security, other factors which should be considered are:

(1) Does it afford convenient approaches for vehicles?

(2) Is it located at a practical distance from the supply and ration point?

(3) What is its proximity to suitable bivouac areas?

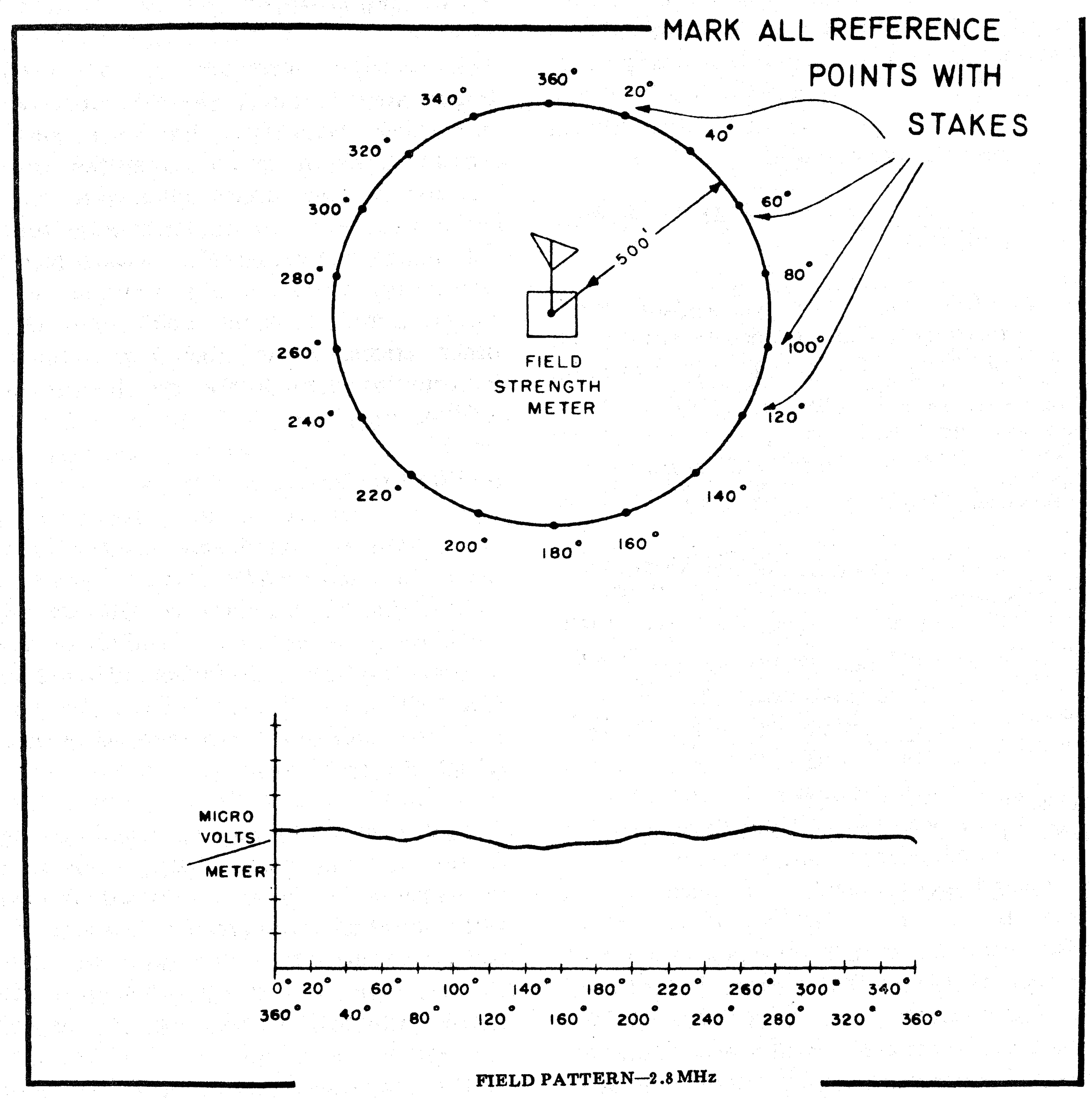


Figure 5–11. Field pattern.

5–13. Improvement of Sites.

The DF site selected, although the best possible, may be far from ideal. Nevertheless, definite measures for improving the site from a technical viewpoint can be undertaken. Areas which are not substantially flat for at least 90 meters from the DF antenna can be leveled off with a bulldozer or grader. If it is impractical or even impossible to level the entire area for 360 degrees coverage, at least those areas within the azimuth arc of primary interest should be flattened. Natural objects such as trees and low vegetation should be cut down or uprooted. Manmade objects and personnel not actually engaged in operating the site should be kept away from the antenna system. Increasing the conductivity

of the ground is another measure that will aid in the overall efficiency of the system. Most DF antenna systems that are not manpacked or vehicular transportable are issued with a counterpoise, which are grounding devices installed under each dipole.

5–14. Periodic Checking of DF Equipment and the Site Selected.

a. Checking Instrumental Calibration and Adjustment. The various calibrations and adjustments of DF equipment described in technical manuals must be performed at regular intervals to ensure continued satisfactory performance and accurate results. Checks should be made at frequent intervals.

b. Daily Check of DF Accuracy. Take daily bearings on known transmitters to ascertain if the accuracy or calibration of the DF site is acceptable. Any appreciable deviation of the DF bearings from the known bearing, or the ones normally obtained, should be investigated immediately.

Section III
DF ERRORS

5–15. General.

This section discusses the various types of errors which may be encountered in DF applications. How these errors may influence the accuracy of the equipment is explained, and how to minimize the influence of these errors to ensure optimum performance is included. An understanding of the information contained in this section will enable the operator to analyze the inferior performance of a DF set, to select and segregate the type or types of errors causing the inferior performance, and, in some cases, to decrease or eliminate the effects of these errors. For purposes of explanation, the various types of errors are grouped as source, path, polarization, site instrumental, and operator errors.

5–16. Source Error.

This error is introduced at or near the transmitting station. It may be caused by the particular type of directional antenna employed, or by ground conditions at the transmitter site which alter the normal radiation pattern of the antenna. If the DF site is more than 15 kilometers away from the transmitting antenna, the magnitude of the source error is usually small compared to other errors. It is, therefore, seldom a contributing factor to the overall accuracy of a DF bearing.

5–17. Path Error.

This is caused by deviations of the radio wave from the great-circle path between the transmitting antenna and the DF site. This deviation is caused by the radio wave being absorbed, reflected, reradiated, refracted, or a combination of these factors. The more important sources of path error and methods of reducing these errors are:

a. Scatter. In some instances, a small portion of the radio wave entering the ionosphere is scattered instead of being gradually bent and returned to the earth. This scattered radiation may be projected in any direction, and returns to earth at random angles (fig. 5–12 and 5–13). This accounts for signals sporadically received in regions that are normally in the skip zone of an HF transmitter (fig. 5–14). Under ordinary operating conditions, errors caused by the reception of scattered waves are not likely to occur. In some cases, however, when a powerful transmitter using a highly directional antenna is transmitting in a direction other than that of the DF site, an azimuth reading taken on this transmission may cause the apparent location of the transmitter to be somewhere along the course of its directed beam rather than in its correct position. This is caused when receiving a wave

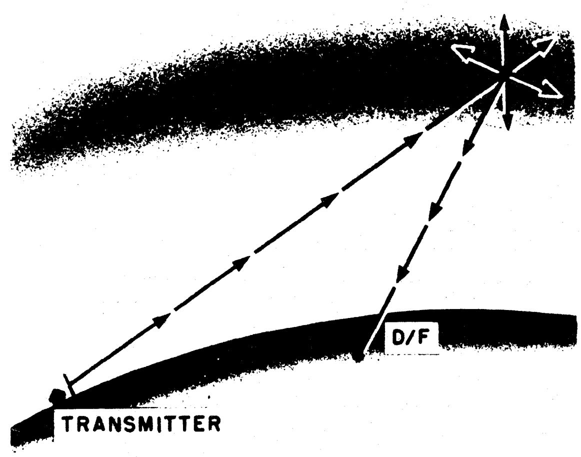


Figure 5–12. Short scatter.

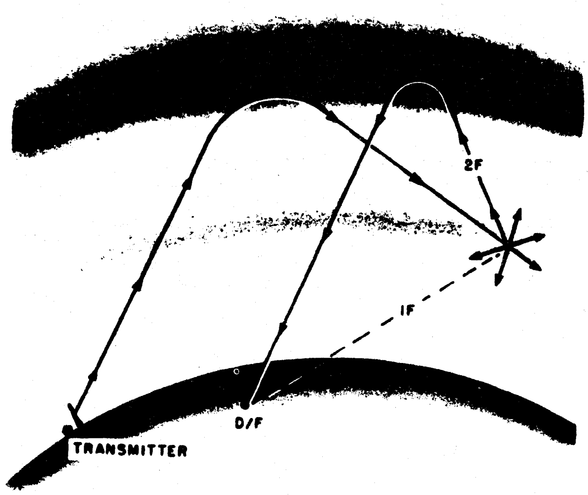


Figure 5–13. Long scatter.

radiated from the scattered source rather than from the transmitter itself.

b. Refraction. Radio waves, being electromagnetic in character, are bent or refracted from their normal path when they pass from one medium to another. A small difference in the conductivity of the surface over which the wave is propagated or a change in the dielectric constant of the medium is sufficient to give rise to refraction. For example, the velocity of a radio wave over sea water is greater than its velocity over land. As a result, when a radio wave crosses a coast line at an oblique angle, its direction is appreciably altered (Capital A, fig. 5–15). The effect is particularly pronounced when either the DF site or the transmitting station is near the coast, especially if high ground intervenes. This effect also varies with the frequency of the wave.

c. Reflection. Incorrect azimuth readings are frequently obtained under conditions which suggest that reflection may sometimes be a contributing cause. Quite large and otherwise unaccountable errors are sometimes produced when a radio wave travels over or close to high cliffs, mountains, or buildings in its path to the direction finder (Capital B, fig. 5–15). Occasionally, conducting strata below the surface of the earth behave in the same manner as surface obstructions by reflecting the wave and causing errors. Generally, errors due to reflection are greatest when the reflecting mediums are in the vicinity of either the transmitter or DF set.

d. Reradiation. This effect occurs primarily as a result of the reradiation of the radio wave by metallic objects that are resonant at the frequency of the received wave. Even when the frequency of these objects is not resonant with the received waves, some reradiation may occur. The flux of such a reradiated wave will have a purely random phase with respect to the flux of the main wave. As a result, there will be a field composed partly of the strong main field and partly of the reradiated fields near the DF receiver, with different phase relations and polarization. These fields may combine to broaden the null, making the azimuth reading

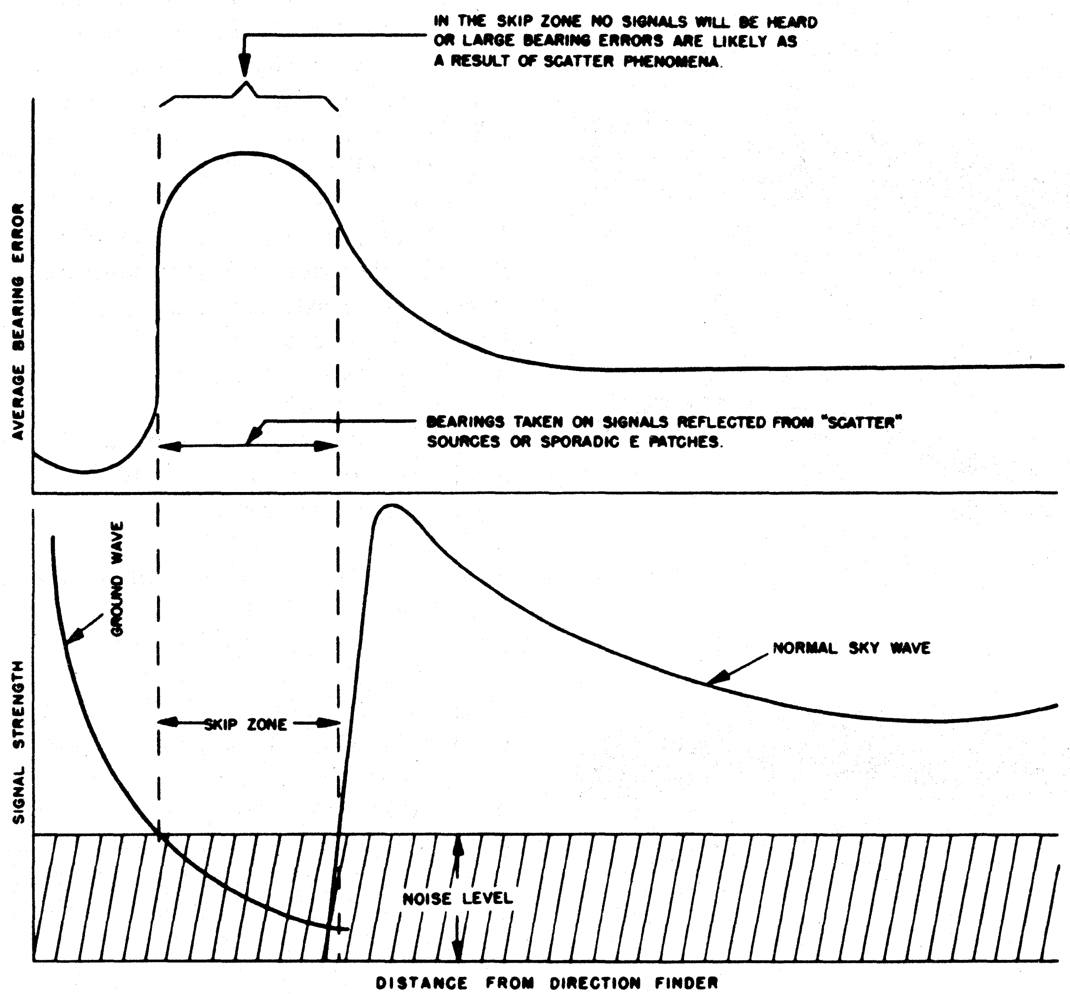


Figure 5–14. Effects of skip zone reception on bearing error.

indefinite and difficult to determine exactly. They also may combine to shift the null, causing error. Reradiation effects usually occur when the reradiating object is in the immediate vicinity of the DF site, although under some conditions, it may occur when the object is at a distance.

e. Methods of Reducing Path Error. There is no practical method of reducing path errors originating from scatter, refraction, reflection, or reradiation. An exception to this can be made when the errors are due to the refraction, reflection, or reradiation of the radio wave in the immediate proximity of the DF site. In this case, the source of error may be removed, its effect adjusted by calibration, or the DF set moved to a more favorable

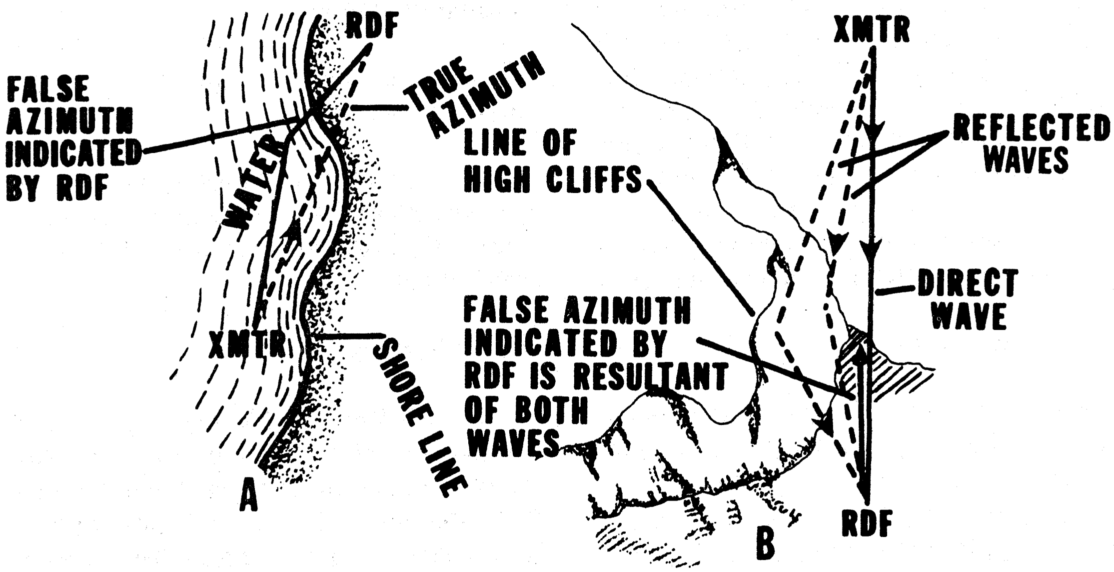


Figure 5–15. Error caused by the refraction and reflection of a radio wave.

location. Calibration for path errors a considerable distance from the DF set is usually not possible.

5–18. Polarization Error.

Polarization error occurs when the undesired component of a radio wave induces voltage in a DF antenna.

a. Effects. This voltage tends to blur the bearing, making the azimuth reading indefinite and difficult to determine. For example, vertical loop and Adcock antennas are designed to receive vertically polarized waves. If the wave is abnormally or randomly polarized (contains both vertically and horizontally polarized components), the voltage induced by the two components may combine to produce the effect mentioned above. The magnitude of the effect will depend upon the ability of the loop or Adcock to discriminate between the desired component (vertically polarized) and the undesired component (horizontally polarized) of the received signal. Other types of antenna systems are designed to receive horizontally polarized waves. With these antennas, polarization errors occur when the vertically polarized components of the radio waves induce voltage. The ways in which radio waves with abnormal polarization originate are described in paragraph **3–5**.

b. Methods of Reducing Polarization Error. The effect of polarization error can be reduced by using a direction finder that is relatively insensitive to incorrectly polarized waves. When randomly polarized waves are received, a direction finder using an Adcock antenna would have less polarization error than a loop set. Additionally, when receiving substantially horizontally polarized waves, a horizontally polarized DF antenna would be superior to a vertically polarized antenna.

5–19. Site Error.

This error occurs in the immediate vicinity of the DF site as a result of many factors, some of which were discussed earlier in this manual. Error is kept to a minimum when the DF equipment is located in the best possible site. Paragraph **5–10** and table *5–1* provide specific installation guidance to eliminate site error. Compensation and calibration are possible for site error, but only if the error is large and reasonably constant without regard to variations in frequency, azimuth, and time.

5–20. Instrument Error.

This error is introduced by the DF equipment itself. The amount of instrument error varies with the design, general condition, and adjustment of the DF equipment. Factors which may introduce instrument error are: low signal-to-noise ratio, antenna effects, and other facets of the equipment discussed in the technical manuals published for the users of the particular sets.

5–21. Operator Errors.

This type of error is self-explanatory. These errors are reduced to a minimum when the operators have sufficient training and experience in operating the specific DF equipment to which they are assigned. In addition, the operator must be alert at all times. When a fading signal is being received, or when the bearing is shifting, the operator must be able to obtain readings at those times when the signal is strongest or most stable. Under adverse conditions, an efficient operator will usually take several different readings and then determine the azimuth by averaging them.

Section IV
PLOTTING METHODS

5–22. Definitions.

a. Line Bearing. This is the angular measurement of the arrival of a radio wave in degrees from true north after the null is obtained. A line bearing is sometimes called an azimuth or a shot.

b. Cut. This is the point of intersection of two DF bearings.

c. Fix. This is the probable location of a target transmitter's antenna when three or more DF bearings have been plotted on a chart or map.

5–23. Plotting.

a. Plotting a Bearing. The simplest method of plotting a bearing is with a protractor and straight edge. Point A in figure 5–16 represents the known location (by grid coordinates) of a DF station. This is entered as a tick mark (.) on the map or overlay. The index of the protractor is placed to coincide with point A and is accurately alined along the north-south grid lines by using dividers or parallel rulers. The bearing taken by the DF station is measured in degrees from true north and is indicated by another tick mark at the appropriate degree on the protractor. The protractor is removed and the straight edge alined along the two tick marks. The bearing is then plotted by drawing a line along the straight edge from the station location through the degree tick mark, extending a sufficient length into the target area so that the enemy transmitter may reasonably be expected to be located along this line.

b. Plotting a Cut. Using the method outlined above, the bearing from a second DF station is plotted. The intersection of the two bearings thus plotted is identified as a DF cut (fig. 5–17).

c. Plotting a Fix. If three DF stations are arranged along a baseline, the protractor may still be used. DF stations A, B, and C are

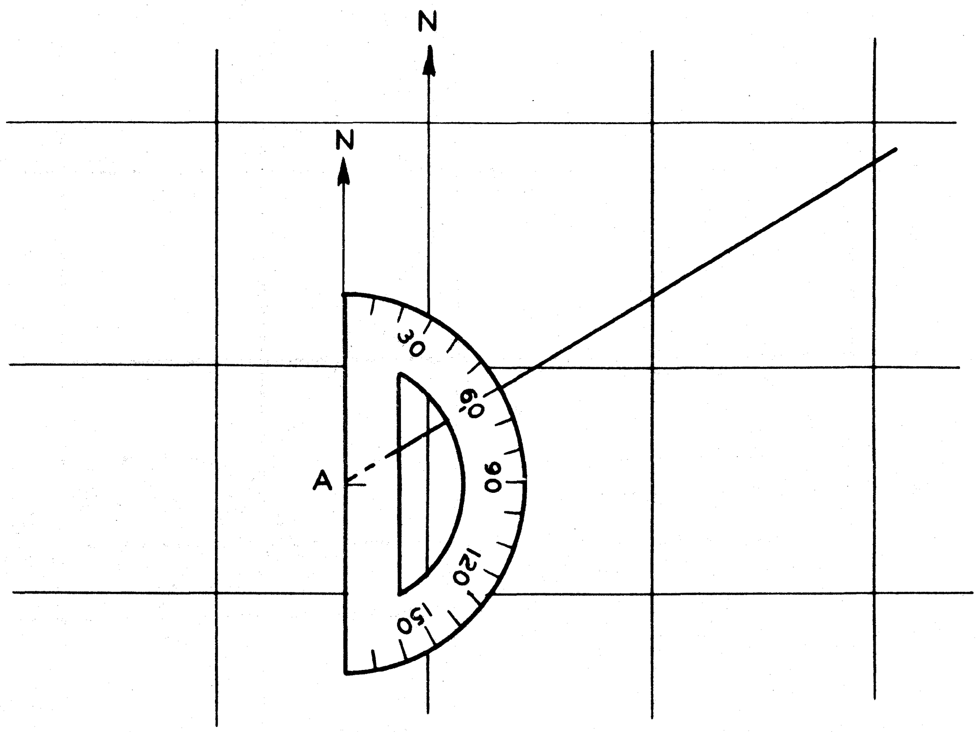


Figure 5–16. Plotting a bearing.

located as shown in figure 5–18, and have reported bearings of 132, 182, and 233 degrees respectively. Again the protractor and straight edge may be used to plot successively the bearings of each DF set at its map location; the lines may be extended to form a small triangle, or join at a point if the fix is perfect. A perfect DF is extremely rare, however, figure 5–18 illustrates a perfect fix.

d. Plotting Control and Evaluation Centers. The plotting procedures described above, while completely valid in terms of accuracy, are somewhat slow and laborious. With the advancement of DF and the greater number of bearings reported by individual stations, the plotter would find it difficult to plot all the DF results. Accordingly, DF plotting centers, with the capability of analysis in depth, have been established. In such centers, plotting boards with the DF stations represented by strings which may be pulled out and lined on calibrated map-edge scales are used. The plotter simply notes the station, the reported bearing, and the calibrated edge scale for the particular reporting station. The compass rose around each DF station has been transferred to the map-edge scales mentioned above. When the string is pulled out and alined along the reported bearing on the map-edge scale, the bearing is plotted. Additional stations are also plotted, and the intersection of the bearings determines the probable target location. Evaluation of DF plotting will be discussed in greater depth in section V. Computerized plotting of DF results is possible in the SWDF nets dealing primarily with the strategic location of targets.

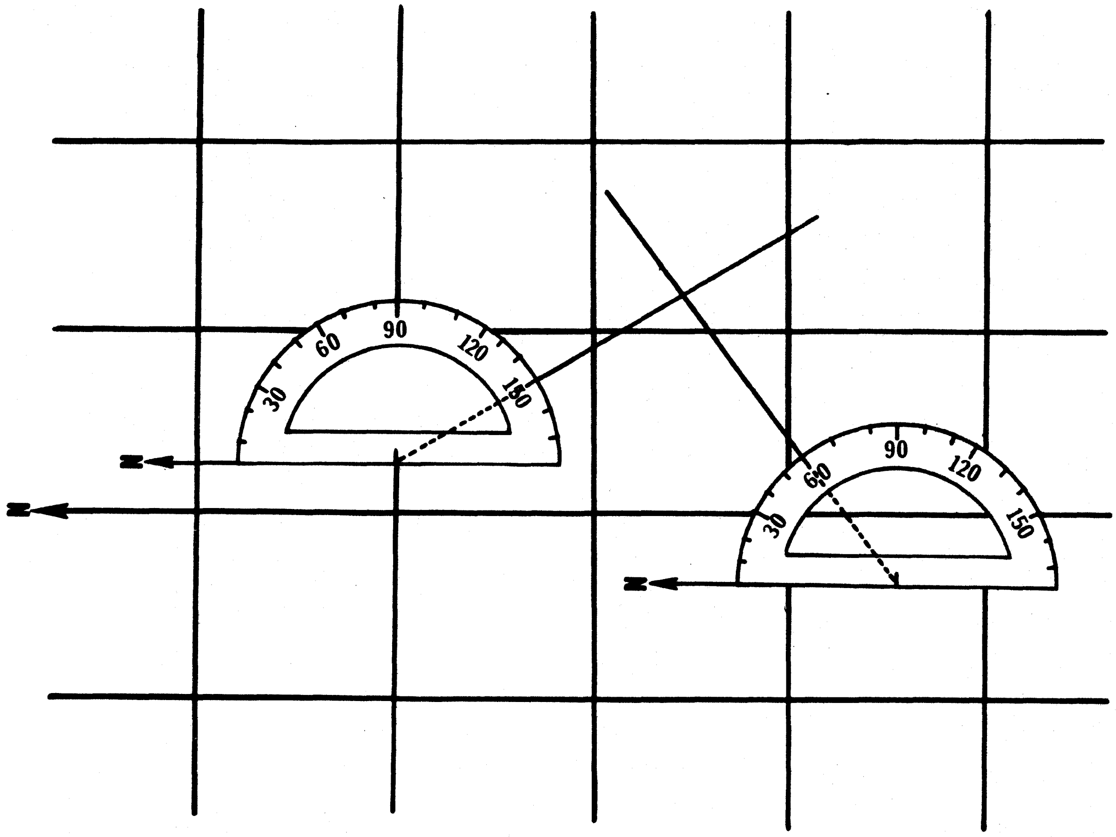


Figure 5–17. Plotting a cut.

5–24. Baselines.

The size and scale of the maps used in plotting will depend upon the range of bearings to be plotted and, of course, upon the length of the DF baseline. The baseline, in turn, is affected by the range of fixes to be obtained, and is limited by the terrain and the DF control net. The limit of an area in which the desired enemy targets will be expected to appear is not definite due to many variables, but experience will dictate the best layout for a given situation. A baseline, ideally, should be the same length as the expected depth of the target area. When these dimensions are observed, at least two of the DF stations will be measuring arriving signals at nearly right angles which is the most desirable.

Section V

EVALUATION OF DF RESULTS

5–25. General.

In section IV, plotting was discussed in general terms with several illustrations given representing near-perfect conditions. In the practical application of DF plotting, the returned bearings are carefully evaluated by the plotters to determine the most nearly correct location of the target of interest. A perfect fix, with three or more bearings

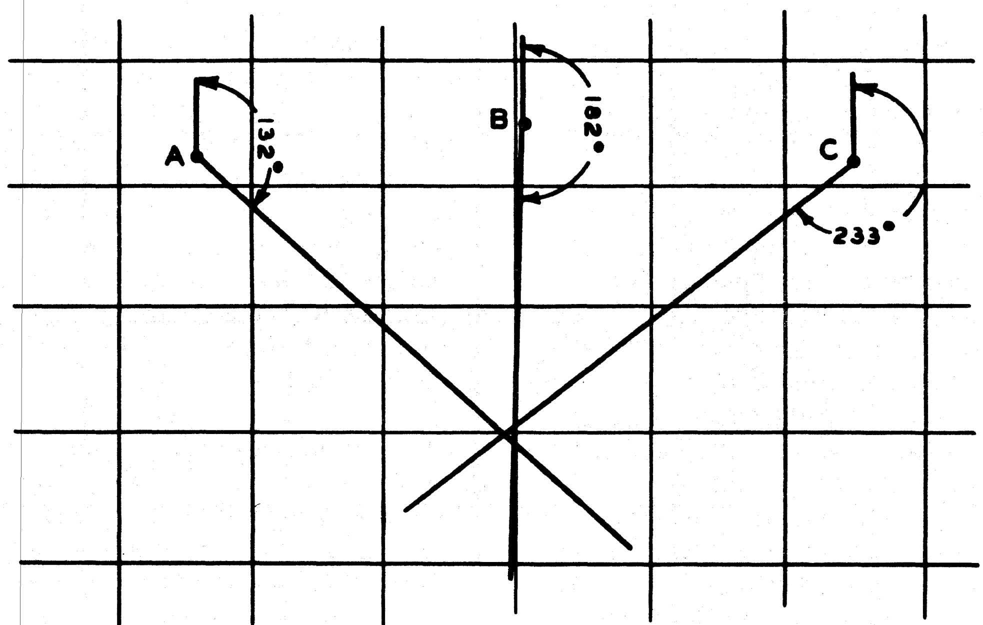


Figure 5–18. Plotting a perfect DF fix.

intersecting at an exact grid location, is so rare it is almost unknown. The plotter has many factors which he must resolve.

5–26. Evaluation by the DF Operator.

Initially, the bearing is obtained by the operator at the DF site and reported to the plotting center or control. The operator's experience, judgement, operating skills, and ability to read the bearings, are factors which affect the accuracy of the reported bearing. A system of evaluating the reliability of a bearing does exist; however, the specific details cannot be discussed within the classification limitations of this manual. Very basically, the operator affixes a designator which reflects a degree of confidence in target identification and a measure of signal conditions at the time the bearing was obtained.

5–27. Evaluation by the Plotter.

A DF plotter is substantially influenced by several human factors in his evaluation of bearings reported from the DF stations in his net. As his experience builds, and reported fix locations are confirmed by enemy contacts and other irrefutable means, the plotter will grant increasing credibility to one DF site over another. Known site error itself will, on many occasions, cause the plotter to reject, or accept on reduced reliability, bearings from certain stations. A change of operating personnel at a particular site, if known to the plotter, may also influence his decision on the reliability to assign a reported bearing. In spite of the standard assignment of reliability indicators, plotting is still very much influenced by these human factors.

Section VI

DETERMINATION OF FIX AREA

5–28. Methods Used to Determine Probable Target Locations.

DF fixes illustrated previously have been "perfect" with all bearings intersecting at an exact grid location. Of course, such a fix seldom occurs because of the inherent errors in DF operations. The continually changing electromagnetic environment of each DF site and the errors discussed previously contribute to these inherent errors. Consequently, fixes obtained after plotting three bearings may appear on the plotting map as indicated in figure 5–19. It is readily apparent that the triangle formed by the three plotted bearings could cover a substantial portion of the tactical area; therefore, methods had to be established to evaluate the most probable location of the target in the triangle. Some of the methods used are the bisection of the medians (sides) of a triangle, bisection of the angles of a triangle, and the Steiner point method. Of these three, the Steiner point method is the most commonly accepted, especially for tactical use. As illustrated in figure 5–20, there is little difference in the three solutions. Strategic DF nets will most often use the visual inspection method, but prior to using this method, a reliable data base must be established.

a. Bisection of the Medians of a Triangle. Evaluating a fix using this method, the plotter must draw a line from the midpoint of each median to the opposing angle. As shown in figure 5–20, a line is plotted from the midpoint of line AB to angle C, another from midpoint of line BC to angle A, and the last line from the midpoint of line AC to angle B. The error triangle solution or probable target emitter location is the point where the three lines intersect (A^1).

b. Bisection of the Angles of a Triangle. Determining the error triangle solution by bisecting the angles of the triangle is shown in figure 5–20. First, the plotter must determine the degree of each angle, then each angle must be bisected. In figure 5–20, the bisecting lines are drawn from angle A to point 1, from angle B to point 2, and last, from angle C to point 3. The solution (B^1) is the point where three lines intersect.

c. Steiner Point. The Steiner point method of determining the location of the target within the error triangle is probably the easiest and most accurate once a template is constructed. Draw a large circle on a sheet of clear plastic and drill a small hole in the exact center. Three lines are etched from the center to the outside of the circle exactly 120 degrees apart, thus trisecting the circle. Lay this template over the error triangle formed after the three bearings are plotted, rotate and maneuver it until each of the 120 degree lines is over the corners of the error triangle. Mark the location (C^1) with a pencil through the hole in the center of the template (fig. 5–20). This mark is reported, by grid coordinates, as the probable target location.

d. Visual Inspection. The visual inspection method of fix evaluation

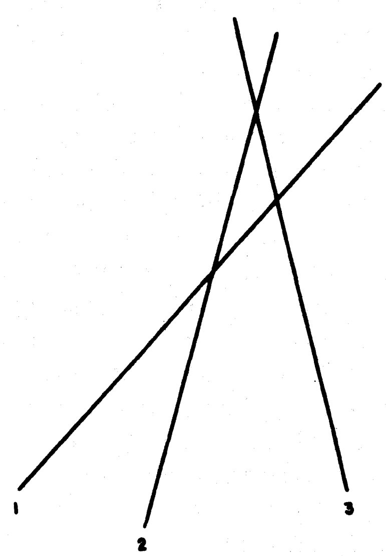


Figure 5–19. Three-station fix, error triangle.

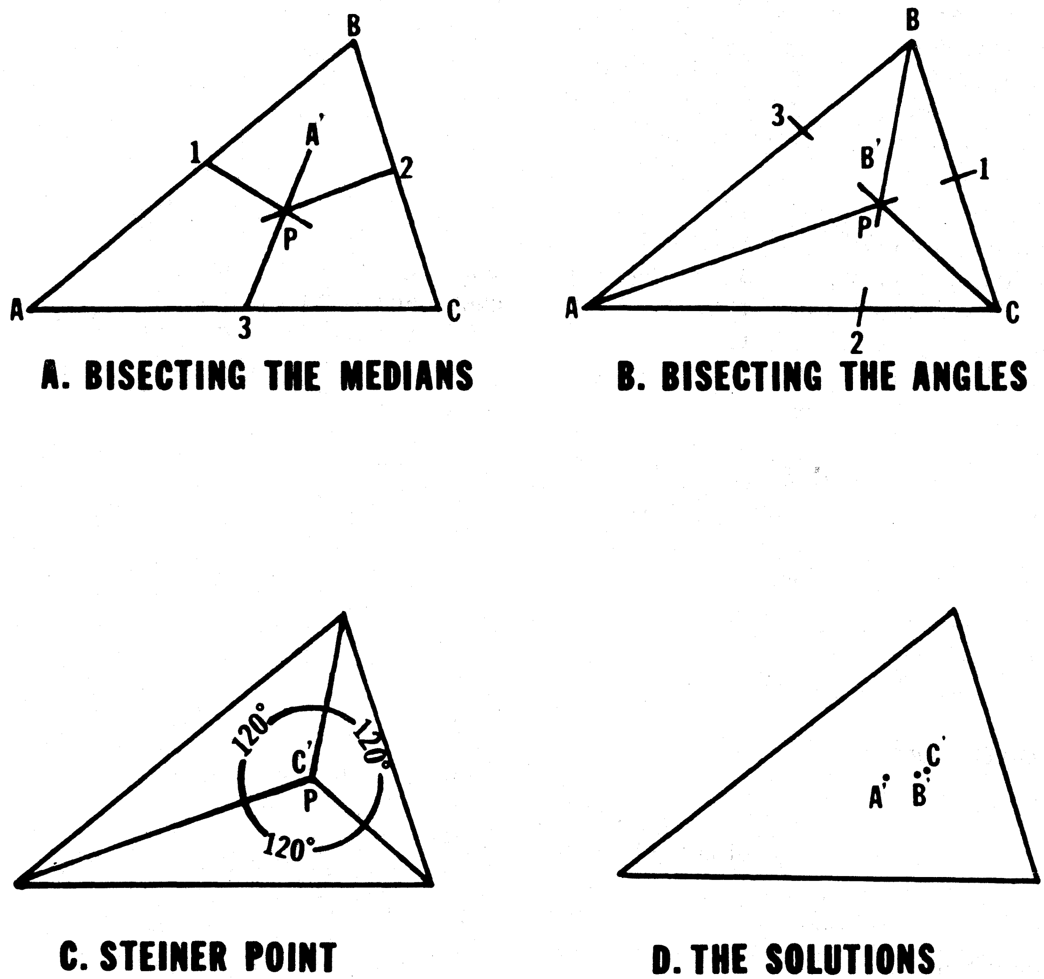


Figure 5–20. Error triangle solution.

encompasses several factors relating to the reported bearings. Paragraph **5–26** described how the operator assigns a classification or evaluation to the bearing. This factor is blended with the known reliability of the DF site based upon past performance. The distance that a radio wave travels before reaching the DF site as well as the terrain features around the DF site are also considered in the visual inspection method of fixing the probable location of a target emitter. Angles that intersect at or near right angles are desirable and weigh heavily in producing the probable location of a target. As illustrated in figure 5–21, if the angle from point A is increased by 10 degrees, the area of increase is greater than that produced when the angle of point B is increased by 10 degrees. This is the reason angles near 90 degrees are desirable. To better illustrate visual inspection, the original bearings from four DF stations have been plotted (figure

5–22). The obvious error triangle is the one formed by lines plotted from bearings reported from stations 1, 2, and 4. However, the analyst in the plotting center knows that stations 1 and 2 have a huge body of water between them and the target area. From the data base, he knows that DF stations 1 and 2 have a plus 10 degrees bearing error for this particular frequency and angle. Using these known facts, the experienced plotter subtracts 10 degrees from the reported bearings of stations 1 and 2. The error triangle with the adjusted bearings is now located in a different and much smaller area formed by lines plotted from stations 1, 2, and 3 as shown in figure 5–22. The analyst has also determined that station 4 reported a bearing for a similar but different signal.

5–29. Deductions Relating to Probable Target Locations.

By using these methods to produce a probable target location, the plotter must examine the

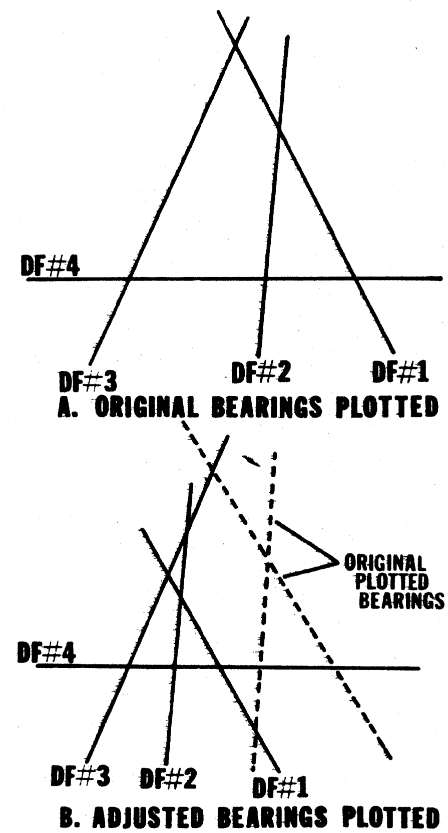


Figure 5–22. Plotting using reported bearings and data base.

map in detail and study the geographical qualities of the fixes that have been produced. Should the location be indicated as the middle of a large lake, there is little likelihood that the transmitter would be accurately located if the target were serving a large headquarters. On the other hand; however, if the target is a low-powered, clandestine station about which little is known, and the fix is made during the hours of darkness, it may very well be accurate; e.g., a man-portable transmitter operating in a boat crossing the lake. If the fix point is located atop an inaccessible crag or butte, the plotter must once again apply a little logic and examine the terrain features adjacent to the indicated location. Transmitters usually serve a command or headquarters and are likely to be located where such troop units would logically be stationed or encamped. Camps,

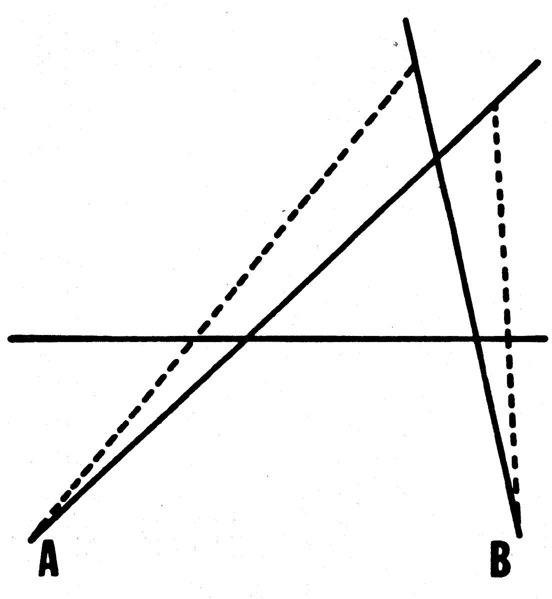


Figure 5–21. Angle increase comparison.

trails, roads, water supplies, and similar terrain features must be evaluated in the formation of fix location.

5–30. Plotting with Four or More Bearings.

a. In larger plotting centers serving many outstations, several bearings may be received on the same target, requiring plotting from more than three bearings. The evaluative process mentioned above still applies. Ultimately, however, the plotter is confronted with a probable location triangle, quadrilateral, or other geometric figure formed by the plotted bearings. The details of these solutions are beyond the scope of this manual.

5–31. Mechanization of DF Plotting.

These methods of plotting to determine a fix point or fix area are predicated on the assumption that the plotting is done on a map board with a protractor and ruler at each DF site, or a string board on which the DF stations have been geographically located. Systematic errors and standard deviation have been interpolated according to all DF stations represented on the plotting board, and the map-edge scale is, therefore, accurate to that station's reported bearings. With the introduction of lightweight, portable computers rugged enough to withstand the exposures of field deployment, DF bearings reported in certain nets are translated into computer language, and determination of the fix areas or fix point is done electromechanically. The least square method of plotting is the basis for all computer plotting, however, because of its complexity, it is beyond the scope of this manual.

CHAPTER 6

Tasking and Reporting

Section I
COMMUNICATIONS REQUIREMENTS FOR DF NETS

6–1. Methods of Communications Within DF Nets.

The methods of communications used by DF nets are landline teletypewriter, radio teletypewriter, CW, and radiotelephone. All of these methods of communications must be secured with cryptosystems. A prime consideration of a DF net is the security and speed with which its users may effectively communicate.

a. The primary method of communications for strategic DF is secure, online teletypewriter using the Defense Special Security Communication System (DSSCS).

b. Methods of communications for tactical DF are CW, secured radio teletypewriter, and radiotelephone.

6–2. Problems of Control.

From the simplest to the most complex DF nets, there are certain functions which must be performed from the time a bearing is requested until the resultant bearings are obtained and the estimated target location is reported. These functions, in a reasonably chronological sequence, are:

a. The bearing to or position of a target station is required for intelligence purposes (mission authorized action). Sufficient information concerning callsigns, frequency, and type of traffic passed must be furnished to permit identification of the target signal. This information is usually obtained from an intercept-search mission which identifies new stations of interest or substantiates the continuance of old stations with an interest in determining possible displacement. The completeness of this information is not always predictable. Generally, however, the DF operator does not spend his time searching the frequency bands for targets.

b. The mission, with all available information on the operation of the target station or net, is given to the radio intercept operator who searches for the desired signal and copies it to obtain traffic and keep the DF controller informed of the station's or net's activities.

c. As soon as the desired station or net is active, the radio intercept operator notifies the DF controller. He also provides the controller with any identifying details not already known.

d. The DF controller notifies all DF operators of the station's or net's activities, callsigns, frequencies, and other identifying information. This takes place over the flash net.

e. Bearings obtained by the DF operator are reported to net control. The reported bearings are plotted and the probable target location given to the commander who authorized or requested the mission. The assignment of the mission to the DF operator and the reporting of the results is accomplished by any of the means of communications mentioned above. If a DF

station happens to be colocated with the intercept facility, communication between the DF controller and the operator is within the confines of the facility, and requires none of the above. When only one DF set is used, only a line bearing can be obtained. In this situation, the commander desiring the bearing is usually in close proximity to the supporting DF site, and requests are made in person, with the results rendered in the same way. This single site DF effort is usually for close tactical support when a ground commander wishes to confirm his contacts or suspicions about the enemy's location. After the inital mission has been assigned to the operator, the controller can employ certain codes (if equipped with online cipher devices) or speak directly to the operator (if speech privacy equipment is available) to keep him informed as to exactly what the target station is doing. This is called "tracking" the station, and is used to ensure positive identification by the operator. Various DF missions will be assigned priorities depending upon the urgency of the tactical situation or the overall intelligence effort. When the missions terminate, the results are forwarded to control over a second net, called the reporting net.

Section II
TASKING AUTHORITY AND COMMAND STRUCTURE OF DF NETS

6–3. General.

Tasking, or mission assignment, is extremely complex, ranging from the tactical commander's request to requirements generated at the national level. A discussion of the detailed generation of missions is not within the scope of this manual. Such information may be obtained, if required, from the liaison officer assigned at each level of command who acts as a resources manager for the units providing DF support.

6–4. Basic Net Requirements for DF Support.

Without regard for the means of communications employed, a DF net requires communications circuits as shown in figure 6–1. The flash net, over which missions are assigned, is indicated by the solid lines, while the reporting net over which mission results are passed, is indicated by the broken lines. This is the basic communications requirement for any DF net. Tracking is conducted over the flash net after the missions are assigned. All bearings are returned over the reporting net.

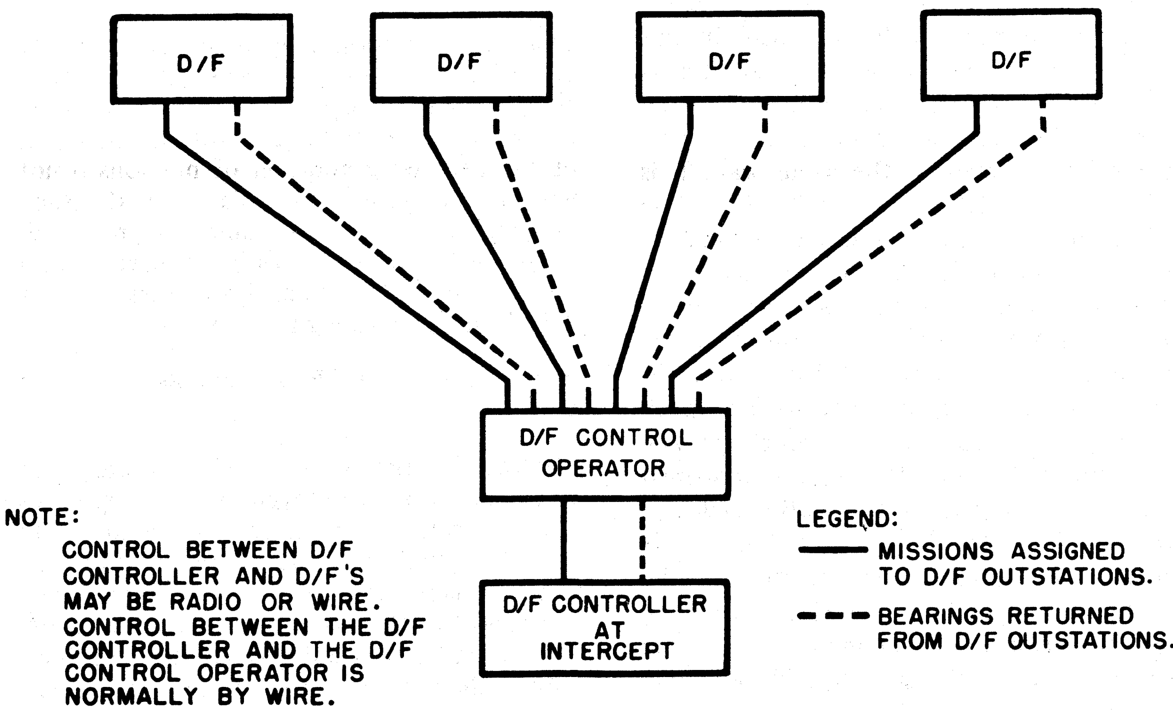


Figure 6–1. DF net control arrangement.

CHAPTER 7

Direction-Finding Computations

Section I

GNOMONIC PROJECTION CORRECTION TECHNIQUES

7–1. General.

The gnomonic projection is the most common map used for long-range DF plotting. Its primary characteristic is the appearance of all great circles as straight lines. Distortion on the gnomonic is minimum at the point of tangency but increases as the distance from the point of tangency increases. For example, the boundaries near the edge of the projection are badly distorted and are practically useless for determining true shapes and distances. This distortion does not affect plotting activities if the DF equipment is located within a four degree radius from the point of map tangency, and bearings can be plotted to any point on the chart without any appreciable error. However, if the DF station is located outside the four degree radius, angular correction must be applied before its bearings can be accurately plotted. The computation methods used to correct this distortion are border coordinates and the corrected compass rose (CCR).

7–2. Border Coordinates.

Border coordinates not only correct angular distortion on a gnomonic chart, but provide what is perhaps considered the most accurate method of plotting DF bearings. Border coordinates divide the perimeter of the gnomonic chart into 1,000 equal spaces, which are denoted by tick marks. Every tenth mark is numbered, starting with 00 at the upper left-hand corner and continuing clockwise to 100. The border coordinates are constructed on the chart so that 00 through 30 are located on the top border; 30 through 50 are located on the right border; 50 through 80 are on the bottom border; and 80 through 100 are located on the left border. The spaces between the tick marks can be mechanically interpolated into tenths, providing a total of 10,000 coordinates for plotting purposes. Tables are constructed for each DF site, providing coordinates for all azimuths. When a bearing is reported by a DF site it is converted to border coordinates and plotted on the gnomonic chart by drawing a line between the coordinate and the DF site. Border coordinates and conversion tables are machine computed and may be obtained on request to higher headquarters. The applicable gnomonic chart number and the exact latitude and longitude of each DF site location must be included in the request.

7–3. Corrected Compass Rose.

a. General. The corrected compass rose is nothing more than a compass rose which has been corrected or expanded to compensate for angular distortion. In other words, the degree marks have been placed closer together or moved farther apart, according to the amount of distortion present. When situated on the gnomonic plotting chart the CCR must have its center exactly over the direction-finding site location. Bearings can then be plotted from the CCR or the rose can be extended to a line around the edge of the map in the same manner as border coordinates.

b. Right-Triangle Method. Constructing a corrected compass rose by the right-triangle

method entails the computation of mathematical formulas and is time consuming; however, this is compensated by the high degree of accuracy and reliability it provides. Since radio waves follow great circle paths, the right-triangle method of error correction is concerned with spherical trigonometry. Under theoretical conditions, the equator and the selected meridian would intersect at a right angle (fig. 7–1). The azimuth from the direction-finding site would intersect both the equator and the selected meridian forming a right triangle. A common logarithm of functions of angles in degrees and minutes table (appendix B) is used to solve the unknown quantities of a spherical right triangle. For additional information on the principles and application of logarithms, reference TM 11–684.

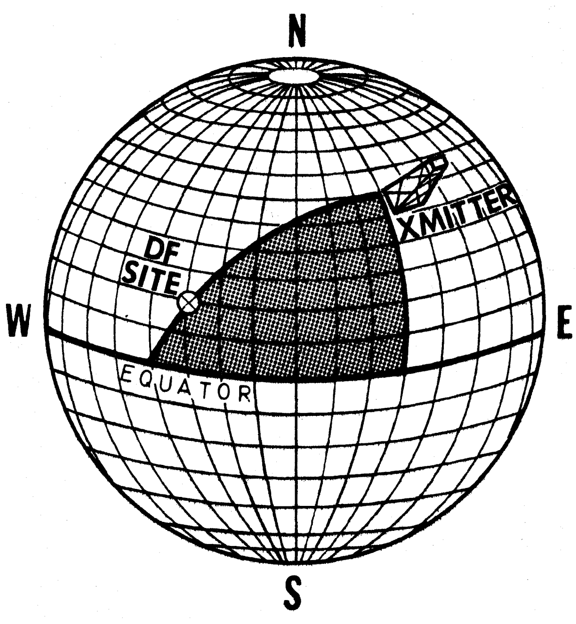


Figure 7–1. Spherical right triangle.

(1) The three known factors of the computation are:

(*a*) The latitude and longitude of the DF site.

(*b*) The longitude of the selected meridian.

(*c*) The desired azimuth.

(2) The selected meridian used during the computation should be in the approximate center of the area of interest. It also should be noted that one single meridian need not be used for the computation of the entire CCR.

(3) Figure 7–2 illustrates the formula used in the right-triangle method of computation.

(*a*) The bottom line marked 0 degrees represents the equator.

(*b*) Line a is the distance in degrees and minutes from the equator to the DF site, or the latitude of the site.

(*c*) Angle B is the desired azimuth which is to be corrected for angular map distortion.

(*d*) Angle A is the angle the desired azimuth makes at the equator. Note that angles A and B do not total 90 degrees as in a true right triangle because the right-triangle method deals with a right triangle only in theory and the functions are computed by spherical trigonometry.

(*e*) Line b is the distance in degrees and minutes of the difference in longitude between the DF site and the intersection of the azimuth with the equator.

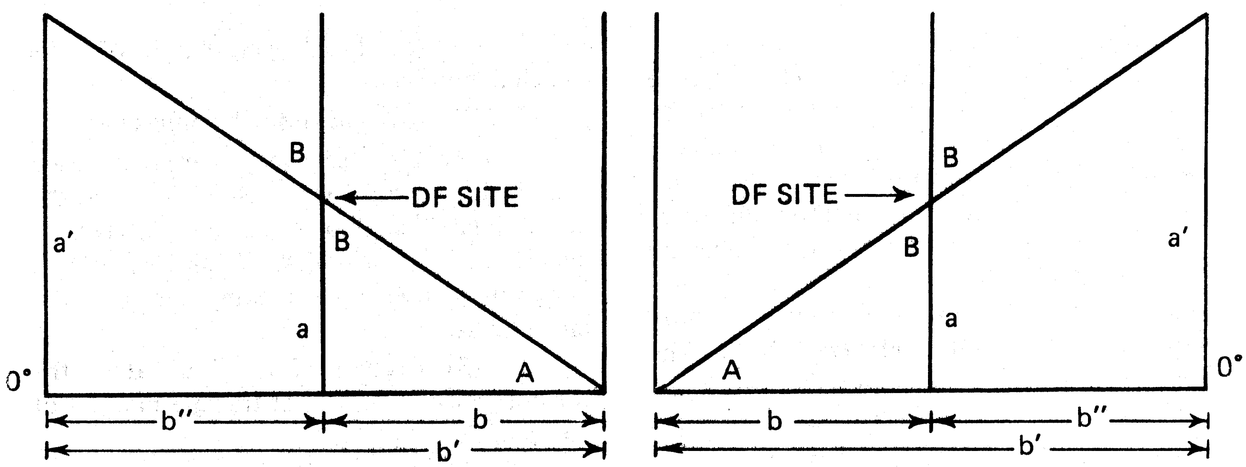
(*f*) Line b″ is the distance in degrees and minutes from the DF site to the selected meridian.

(*g*) Line b′ is the difference in longitude of the intersection of the azimuth with the equator and the selected meridian. Or, line b′ is the sum of lines b and b″.

(*h*) The value of a′ represents the latitude at which the bearing will intersect the selected meridian.

c. Common Logarithms of Functions of Angles in Degrees and Minutes Table.

(1) *Degrees.* Each page of the appendix B table is computed for eight



B= __________ a= __________ b''= __________ b= __________

a'= __________ A= __________ b'= __________

(log tan b) = (log sin a) – (log cot B)

log sin a: __________

log cot B: __________

Diff: __________ = log tan b   b= __________

(log cos A) = (log cos a) + (log sin B)

log cos a: __________

log sin B: __________

Sum: __________ = log cos A   A= __________

(log tan a') = (log sin b') – (log cot A)

log sin b': __________

log cot A: __________

Diff: __________ = log tan a'   a'= __________

Figure 7–2. Right triangle computation worksheet.

different angles, of which four are indicated in the upper left-hand corner and four in the lower right-hand corner. The fact that one page is sufficient for the functions of eight different angles is a result of the properties of trigonometric functions. For example, the sine of 0 degrees is numerically equal to the sine of 180 degrees and the cosine of 90 degrees is equal to the cosine of 270 degrees.

(2) *Minutes.* The minutes for each angle are found in the columns headed by the mathematical sign for minutes ('). The minutes for the angles in the upper left-hand corner are read *down* the left minute column. The minutes for the angles in the lower right-hand corner are read *up* the right minute column.

(3) *Use of the tables.*

(*a*) To determine the logarithm of an angle:

1. Locate the page containing the angle of the trigonometric function.

2. Follow the angle's minute column up or down, as required, until the exact minute reading is located.

3. Determine which function is appropriate by consulting the legend either at the top or the bottom of the table. Angle functions are *opposite* each angle or degree reading. The number found at the intersection of the function column and the logarithm row opposite the minute column is the logarithm of that angle.

(*b*) To determine the angle of a logarithm:

1. Locate the logarithm which is *nearest* the given logarithm in the appropriate function column.

2. The minute value will be selected from either the corresponding number in the left minute column or the right minute column.

3. Note the corresponding angles of the function column, top left-hand corner and bottom right-hand corner, and select the *lowest* of the four angles. If the selected angle is at the top of the page, read the minute value from the left minute column. However, if the selected angle is taken from the bottom of the page, read the minute value from the right minute column.

d. Right-Triangle Method Example. The desired azimuth or angle B which is to be corrected for angular distortion is 10 degrees. The latitude of the DF site or line a is 36 degrees. The difference in longitude between the DF site and the selected meridian, or b'', is 5 degrees. (Reference appendix B for logarithm table.)

Step 1. Find b:

(log sin a) – (log cot B) = (log tan b)

log sin 36° = 9.76922–10
log cot 10° = 0.75368
log diff = 9.01554–10
log tan b = 9.01554–10
b = 5° 55'

Note. Always select the *lowest* degree and minute reading.

Step 2. Find b':

(b'') + (b) = (b')

b'' = 5°
b = 5° 55'
b' = 10° 55'

Step 3. Find A:

(log cos a) + (log sin B) = (log cos A)

log cos 36° = 9.90796–10
log sin 10° = 9.23967–10
log sum = 19.14763–20
log cos A = 9.14763–10
A = 81° 55'

Step 4. Find a':

(log sin b') – (log cot A) = (log tan a')

log sin 10° 55' = 9.27734–10
log cot 81° 55' = 9.15236–10
log diff = 0.12498
log tan a' = 0.12498
a' = 53° 08'

Step 5. A straightedge alined with 53 degrees and 8 minutes latitude on the selected meridian will indicate the corrected azimuth for 10 degrees. When

constructing a corrected compass rose a tick mark should be placed on the compass rose and numbered 10 degrees, or a tick mark placed on the edge of the plotting chart and numbered 10 degrees.

(1) It is apparent that logarithm tables are constructed in such a manner so that the area from 0 to 90 degrees will represent the entire 360 degree circle. Any computation using *X* degrees east as the selected meridian will also be correct for *X* degrees west and both reciprocals. Therefore, any single computation will yield four azimuths; 90 computations are required to complete the entire compass rose.

(2) A problem area may arise when computing desired azimuths around 90 or 270 degrees. To eliminate confusion, subtract the value of (b) from 90 degrees and complete the computations normally. This procedure should also be used approximately 5 degrees on either side of the 90 or 270 degree azimuth which will ensure standard accuracy.

Section II

GREAT CIRCLE AZIMUTHS

7–4. General.

Radio waves follow great circle paths between the transmitting and receiving antennas. When the exact location of the signal source is known, it is possible to compute the true or great circle azimuth and distance (GCAD) from the point of signal origin to any other point receiving the signal on the surface of the earth. The computations of great circle azimuths are based on spherical trigonometry and may be computed using the dead reckoning altitude and azimuth table in appendix C. This method is simpler and much faster than using other logarithmic methods and is accurate to within one-half a minute. Greater accuracy is possible by interpolating between table functions.

7–5. Dead Reckoning Altitude and Azimuth Table.

The dead reckoning altitude and azimuth table is arranged in parallel "A" and "B" columns. The "A" columns contain log cosecants multiplied by 100,000 and the "B" columns contain log secants multiplied by 100,000. The "A" columns decrease in value from the front of the table toward the rear, while the "B" columns increase in value from the front of the table to the rear. When determining degrees and minutes from the top of the table, read the minutes from the *left-hand* column. However, when reading the degrees and minutes from the bottom of the table, read the minutes from the *right-hand* column. It should also be noted that if the desired degrees and minutes exceed 180 degrees, it is necessary to subtract 180 degrees before entering the table.

7–6. Great Circle Azimuth and Distance Computation.

a. General. Great circle azimuth and distance computations are based on spherical trigonometry. A terrestrial triangle has curved sides and is commonly referred to as a spherical triangle. Refer to figure 7–3 and you will see that the shaded portion of the illustration is a spherical triangle. The determination of the true azimuth and distance is reduced to simply completing the worksheet (fig. 7–4) using the dead reckoning altitude and azimuth table.

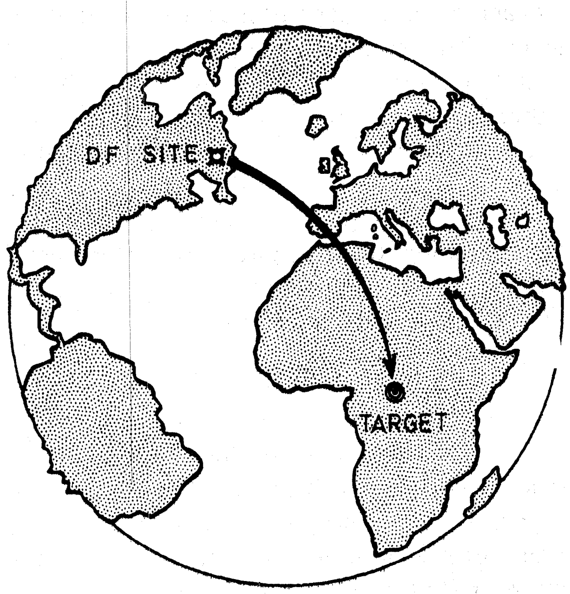
b. Formula symbols. The following symbols are used in the GCAD formula (fig. 7–3):

(1) L or lat is the latitude of the initial position or the DF site.

(2) L′ or lat′ is the latitude of the final position or the check station.

(3) $\angle$B is the great circle azimuth from the check station to the DF site.

(4) D arc is the great circle distance, in minutes of arc, between the target and the DF site. (One minute of arc equals one nautical mile.)



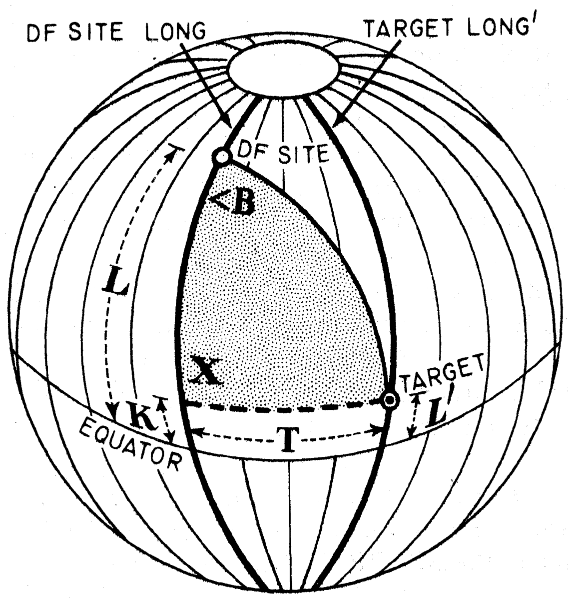


Figure 7–3. Spherical triangle.

(5) X is a factor introduced to simplify the computation and represents that point at which a great circle constructed perpendicular to the target's meridian crosses the meridian of the DF site.

(6) K is the latitude of point X or the arc from X to the equator (assumes the name of the latitude of the final position.)

(7) KL is the difference between K and L.

(8) Long is the longitude of the DF site.

(9) Long' is the longitude of the check station.

c. *Special Rules.* The fact that D arc may be greater than 90 degrees has necessitated the following rules.

(1) *Rule 1.* When L and L' are the same name (north or south) the following procedures are applicable.

(*a*) When T is *greater* than 90 degrees, select the K value from the bottom of the table. When T is *less* than 90 degrees, select the K value from the top of the table.

(*b*) Record ∠B from the top of the table when K is *greater* than L. When K is *less* than L select ∠B from the bottom of the table.

(*c*) D arc is recorded from the top of the table *except* when T and KL are *both greater* than 90 degrees.

(2) *Rule 2.* When L and L' are different names the following procedures are applicable.

(*a*) When T is *greater* than 90 degrees select the K value from the bottom of the table. When T is *less* than 90 degrees select the K value from the top of the table.

(*b*) Record ∠B from the bottom of the table except when KL is *greater* than 180 degrees.

(*c*) D arc is recorded from the bottom of the table *except* when T and KL are both *less* than 90 degrees.

(*d*) When KL exceeds 180 degrees, subtract 180 degrees before making a table computation.

(3) *Rule 3.* Computation of ∠B.

(*a*) When the initial position is in the *Northern Hemisphere* and is *west* of the final position, ∠B is the true bearing. If the initial position is *east* of the final position, ∠B is subtracted from 360 degrees to obtain the true bearing.

(*b*) When the initial position is in the *Southern Hemisphere* and is *west* of the final position, subtract ∠B from 180 degrees. If the initial position is *east* of the final position, add 180 degrees to ∠B to obtain the true bearing.

d. GCAD Worksheet. To facilitate the computation process, a GCAD worksheet is illustrated in figure 7–4. It is divided into a heading and the step-by-step procedure for determining true azimuth and distance. An explanation of the worksheet and the GCAD formula follows.

(1) The heading contains the latitude and longitude of the direction-finding site and the selected check station. The following abbreviations are used:

(*a*) FROM: The name of the DF site.

(*b*) LAT or L: The latitude of the DF site.

(*c*) LONG: The longitude of the DF site.

(*d*) TO: The name of the target station.

(*e*) LAT′ or L′: The latitude of the target station.

(*f*) LONG′: The longitude of the target station.

(*g*) To determine T, the following procedures should be followed:

1. If LONG and LONG′ are in the same hemisphere, (same names) *subtract* to determine the T value.

2. If LONG and LONG′ are in different hemispheres, (different names) *add* to determine the T value.

(2) The remainder of the worksheet is divided into the DEGREES/MINUTES column and COL–1 through COL–4. The mathematical function is indicated at the top of each column. Logarithms are entered at the spaces "A" and "B" beginning with COL–1 and the appropriate function performed. If other logarithm tables are used instead of the dead reckoning altitude and azimuth table, column A will equate to the log cosecant and column B will equate to the log secant. Prior to beginning the computation, enter the T value in the appropriate space under the DEGREES/MINUTES column.

e. Computation Procedures.

(1) *COL–1.*

(*a*) Locate the T value in the dead reckoning altitude and azimuth table (appendix C). Enter the figure found under the corresponding A column in the appropriate space under COL–1.

(*b*) Enter L′ in the appropriate space under the DEGREES/MINUTES column.

(*c*) Locate the L′ value in the table. Enter the corresponding B column number in the appropriate space under COL–1.

(*d*) Add the COL–1 A and B values. Enter the result under the final A space in COL–1.

(2) *COL–2.*

(*a*) Locate the L′ value in the table. Enter the corresponding A column figure in the appropriate space under COL–2.

(*b*) Locate the COL–1 final A value in the table. Enter the corresponding B figure in the appropriate space under COL–2.

(*c*) Subtract the COL–2 B value from the COL–2 value. The result is entered as the final COL–2 A value.

(*d*) Locate the final COL–2 A value in the table. The corresponding degrees and minutes will be entered as the K value under the DEGREES/MINUTES column.

Note. Before the K value is determined, refer to the special rules 1 or 2 and determine which is applicable to the GCAD computation.

FROM: ______ TO: ______

LAT: ______ LAT′: ______

LONG: ______ LONG′: ______

T is determined by the following conditions: If long and long′ are the same name SUBTRACT. If long and long′ are different names ADD.

T ______

DEGREES/MINUTES	COL–1 (ADD)	COL–2 (SUBTRACT)	COL–3 (ADD)	COL–4 (SUBTRACT)
T:	A:			
L′:	B:	A:		
	A:	B:	B:	A:
K:		A:		
L:				
KL:			B:	
D ARC:			B:	A:
60 X DEGREES				A:
+ MINUTES +				<B
TOTAL				
TRUE AZIMUTH				

If other logarithm tables are used instead of dead reckoning altitude and azimuth tables, column A equates to log consecant, and column B equates to log secant.

Figure 7–4. GCAD computation worksheet.

(3) *COL–3.*

(*a*) The first COL–3 B value is a repeat of the COL–2 B value.

(*b*) Enter the LAT or L in the appropriate space under the DEGREES/ MINUTES column.

(*c*) Determine the KL value under the DEGREES/MINUTES column, by subtracting the L or LAT value from the K value if the same name. Add K and L if different names.

(*d*) Locate the KL value in the table. Enter the corresponding B column value in the appropriate COL–3 space.

Note. If rule 2 is applicable to the computation, and the KL value exceeds 180 degrees, subtract 180 degrees before entering the table.

(*e*) Add the COL–3 B values. Enter the result as the final COL–3 B value.

(*f*) Locate the final COL–3 B value in the table. Enter the corresponding degrees and minutes as the D arc value under the DEGREES/MINUTES column.

Note. Refer to the applicable rule to determine if the D arc value is taken from the top or the bottom of the table.

(4) *COL–4.*

(*a*) The first COL–4 A value is a repeat of the final COL–1 A value.

(*b*) Locate the final COL–3 B value in the table. Enter the corresponding A value in the appropriate COL–4 A space.

(*c*) Subtract the COL–4 A values and enter the difference in the space provided.

(*d*) Locate the final COL–4 A value in the table. Enter the corresponding degrees and minutes as the COL–4 B value.

Note. Again refer to the applicable rule to determine if ∠B is taken from the top or the bottom of the table, and if that value is the true azimuth.

(5) *Distance.* To compute the great circle azimuth distance:

(*a*) Multiply the number of D arc degrees by 60.

(*b*) Add the D arc minutes to the result. The sum indicates the distance in nautical miles. To obtain statute miles, multiply the nautical miles by 1.15.

f. GCAD Example. Determine the great circle azimuth and distance from Hetricks Villa, USA to London, England. The following information is provided.

Hetricks Villa, USA	Latitude:	42° 33′ North
	Longitude:	71° 36′ West
London, England	Latitude:	51° 32′ North
	Longitude:	00° 05′ West

Before beginning the computation, determine which rule is applicable. Since LONG and LONG′ are the same name, *West,* rule 1 will apply.

Step 1. Determine the T value. Since LONG and LONG′ are the same name, *West,* subtract to find the difference.

Hetricks Villa	LONG:	71° 36′
		−
London	LONG′:	00° 05′
	T =	71° 31′

Step 2. Locate the T value, 71° 31′, in the dead reckoning and azimuth table. The corresponding COL–1 A value is 2300.

Step 3. Locate the L′ value, 51° 32′, in the table. The corresponding COL–1 B value is 20617.

Step 4. Add the COL–1 A and B values. The result, or 22917, is the final COL–1 A value.

A	2300
+	
B	20617
	22917

Step 5. Locate the L′ value, 51° 32′, in the table. The corresponding COL–2 A value is 10625.

Step 6. Locate the COL–1 final A value, 22917, in the table. The corresponding COL–2 B value is 9292.

Step 7. Subtract the COL–2 B value, 9292, from the COL–2 A value, 10625. The remainder is 1333 and the final COL–2 A value.

A	10625
–	
B	9292
	1333

Step 8. Locate the final COL–2 A value, 1333, in the table. The corresponding degrees and minutes, 75° 52′ 30″ represents the K value.

Note. Refer to rule 1a to determine if K is selected from the top or the bottom of the table.

Step 9. Record the first COL–3 B value as 9292 since it is a repeat of the COL–2 B value.

Step 10. Enter the value for LAT, or 42° 33′, under the DEGREES/MINUTES column in the appropriate space.

Step 11. Determine the value for KL by subtracting LAT, 42° 33′ from the K value, 75° 52′ ii. The remainder is 33° 19′ 30″.

K	75° 52′ 30″
–	
LAT	42° 33′
KL =	33° 19′ 30″

Step 12. Locate the KL value, 33° 19′ 30″, in the table. The corresponding COL–3 B value is 7802.

Step 13. Add the COL–3 B values. The sum and final B value is 17094.

B	9292
+	
B	7802
B =	17094

Step 14. Record the first COL–4 A value as 22917 since it is a repeat of the final COL–1 A value.

Step 15. Locate the COL–3 final B value, 17094, in the table. The corresponding COL–4 A value is 13185.

Step 16. Subtract the COL–4 A value, 13185, from 22917. The final COL–4 value is 9732.

A	22917
–	
A	13185
A =	9732

Step 17. Locate the COL–4 final A value, 9732, in the table. Again refer to rule 1 and determine if ∠B is taken from the top or the bottom of the table. Since K is greater than L, ∠B is selected from the top of the table. Therefore, ∠B or the true azimuth from Hetricks Villa to London, England is 53° 03′ 30″. Again refer to the rule and determine if ∠B is the true bearing. As the initial position is west of the final position, 53° 03′ 30″ is the true azimuth.

Step 18. To determine D arc, locate the final COL–3 B value in the table. Refer to rule 1 to determine if D arc is taken from the top or the bottom of the table. Since T and KL are both less then 90 degrees, D arc is taken from the top of the table and is 47° 34′ 30″.

Step 19. To compute the distance from the initial to the final position in nautical miles, multiply D arc by 60. To obtain statute miles, multiply the total nautical miles by 1.15.

D arc = 47° 34′ 30″		
47 X 60 =		2820
	+	34.5
Total nautical miles =		2854.5
		2854.5
		x 1.15
		142 725
		285 45
		2854 5
Total statute miles =		3282.675

Section III

STATISTICAL FACTORS

7–7. General.

Statistical analysis is an invaluable management tool for measuring direction-finding performance. Through the proper application of statistics, an estimate of the amount of error found in individual bearings can be provided, as well as the probable amount of error of the site, or even

the complete direction-finding net. Normally, plotting and evaluation activities are responsible for performing accuracy studies. However, direction-finding supervisors and analysts must be knowledgeable of statistical analysis procedures and must be able to compute the analytical computations outlined in this chapter.

7–8. Systematic Error.

Systematic error (SE) represents the difference between the true bearing and the mean bearing of a transmitter. The true bearing is determined by computing a great circle azimuth from the DF site to the selected target station. The average bearing is determined by taking a large number of bearings on the selected transmitter, a minimum of 200, and computing the average or mean bearing of the sample.

a. Consideration should be given to the following criteria when selecting a check station.

(1) The frequency should be compatible with operational targets.

(2) The location should be within the area of interest or a very close proximity thereof.

(3) The distance should not be significantly different than that of operational targets.

b. Systematic error is computed using the formula SE = Bearing Mean (BM) minus Bearing True (BT).

(1) BM is the mean bearing between the DF site and the selected check station.

(2) BT is the true bearing between the DF station and the selected check station.

c. The following steps outline the procedure for computing systematic error.

Step 1. Visually inspect the reported bearings and eliminate the obviously wild ones.

Step 2. Mathematically compute the mean bearing from the remaining bearings.

Step 3. Eliminate all bearings which deviate more than plus or minus 8 degrees from the computed mean bearing.

Step 4. Recompute the mean bearing.

Step 5. Determine the difference between the mean and true bearings. The difference is the systematic error.

Note. Systematic error must always be expressed as a negative or positive error. If the mean bearing is smaller than the true bearing, the error is negative. However, if the mean bearing is larger than the true bearing, the error is positive.

d. The following example illustrates the computation of systematic error using the formula SE = BM – BT. The true azimuth of the check station is 031 degrees. The following bearings were observed on the selected check station: 029°, 025°, 032°, 029°, 034°, 032°, 030°, 028°, 034°, and 027°.

Note. In practical applications at least 200 bearings must be obtained on the selected check station.

Step 1. A visual inspection proves there are no obvious wild bearings.

Step 2. Compute the mean bearing.

029°
025°
032°
029°
034°
032°
030°
028°
034°
027°
300 / 10 = 030°

Steps 3 and 4. Since there are no bearings which deviate over plus or minus 8 degrees from the computed mean bearing, proceed to step 5.

Step 5. Determine the difference between the mean and true bearings. The difference is the systematic error.

SE = BM – BT
SE = 030° – 031°
SE = –001°

7–9. Variance.

Variance is used as a reliability factor and indicates the quality of bearings used in the computation of the mean bearing. Variance provides the measure of spread, or the dispersion of bearings around the mean bearing. The analysis of either site or individual operator variance on selected check stations provides the supervisor with an additional management tool for evaluating efficiency.

a. The formula for computing variance is:

$$\frac{(BM - BO)^2.}{N}$$

(1) Σ indicates the algebraic sum.

(2) $(BM - BO)^2$ is the observed bearing subtracted from the mean bearing. The difference or remainder is then squared.

(3) N is the total number of bearings within plus or minus 8 degrees of the mean bearing.

b. The following steps outline the procedure for computing variance.

Step 1. Visually inspect all the reported bearings and eliminate the obviously wild ones.

Step 2. Mathematically compute the mean bearing from the remaining bearings.

Step 3. Eliminate any of the remaining bearings which deviate more than plus or minus 8 degrees from the computed mean.

Step 4. Recompute the mean if necessary.

Step 5. Determine the deviation of each observed bearing from the mean bearing and square each deviation.

Step 6. Add the squared deviations. Divide the sum by the total number of bearings used. The result is the variance.

Note. Due to the squaring process in step 5, variance has no sign.

c. The following bearings were observed on a selected check station: 330°, 326°, 333°, 334°, 325°, 330°, 331°, 329°, 328°, and 334°.

Note. In practical applications at least 200 bearings must be obtained on the selected check station.

Step 1. A visual inspection proves there are no obvious wild bearings.

Step 2. Compute the mean bearing.

330°
326°
333°
334°
325°
331°
330°
329°
328°
334°
3300 / 10 = 330°

Steps 3 and 4. Since there are no bearings which deviate over plus or minus 8 degrees from the computed mean, proceed to step 5.

Step 5. Determine the deviation of each observed bearing from the mean bearing and square each deviation.

BM		BO		Remainder		Squared
330°	–	330°	=	0^2	=	0
330°	–	326°	=	4^2	=	16
330°	–	333°	=	-3^2	=	9
330°	–	334°	=	-4^2	=	16
330°	–	325°	=	5^2	=	25
330°	–	331°	=	-1^2	=	1
330°	–	330°	=	0^2	=	0
330°	–	329°	=	1^2	=	1
330°	–	328°	=	2^2	=	4
330°	–	334°	=	-4	=	16

Step 6. Add the squared deviations and divide by the number of bearings used. The result is the variance.

```
 0
16
 9
16
25
 1
 0
 1
 4
16
--
88 / 10 = 8.8
```

The variance is 8.8.

7–10. Square Root.

Before standard deviation (SD), another direction-finding statistical factor, can be addressed it is necessary to be able to manually compute square root. Although pocket calculators and other machine aids can perform this function much faster, the need for manual computation of square root may arise.

a. The following steps outline the procedure for obtaining the square root of the number 3.4.

Step 1. Starting at the decimal point, mark off the digits in pairs in both directions. Add zeros as necessary.

$\sqrt{\overset{\frown}{03}.\ \overset{\frown}{40}\ \overset{\frown}{00}}$

Step 2. Place the decimal point for the answer directly above the decimal point that appears under the radical sign.

```
  □
√03. 40 00
```

Step 3. Determine by inspection the largest number that can be squared without exceeding the first pair of digits – 03. The answer is 1, since the square of any number larger than 1 will be greater than 03. Place the 1 above the first pair of digits.

```
 1.
03. 40 00
```

Step 4. Square 1 obtaining 1 and place it under the 03. Subtract 1 from 03 obtaining 2. Bring down the next pair of digits.

```
  1.
√03. 40 00
  [1]
  [2] 40
```

Step 5. Double the answer or quotient of 1 obtaining 2. Place the 2 to the immediate left of the 240. Determine the number that can be multiplied by 2 and that same number and not exceed 240. The answer is 8 since 28 X 8 = 224. The number 9 would prove to be too large since 29 X 9 = 261. Place the number 8 to the right of the decimal in the quotient. Subtract the 224 from 240 and bring down the next pair of numbers – 00.

```
        1.   8
      √03.  40   00
         1
  2[8]   2  40
         2  24
            16   00
```

Step 6. Double the quotient 18, disregarding the decimal point, obtaining 36. Place the 36 to the left of the 1600. Determine the number that can be multiplied by 36 and that same number and not exceed 1600. The answer is 4 as 364 X 4 = 1456. The number 5 would be too large since 365 X 5 = 1825. Place the 4 above the second pair of digits.

```
        1.   8   [4]
      √03.  40   00
         1
   28    2  40
         2  24
  36[4]     16   00
            14   56
             1   44
```

b. Depending on the degree of accuracy desired, one can continue the process indefinitely by adding zeros. For direction-finding purposes, two places to the right of the decimal are sufficient. For example, $(1.84)^2 = 3.3856$.

7–11. Standard Deviation (SD).

a. Standard deviation is perhaps the best statistical method of evaluating direction-finding site performance. Systematic error is indicative of average error, but standard deviation is representative of site reliability. SD is a probability figure which indicates the spread of bearings on one or more targets. In this respect, the smaller the number or SD, the greater the reliability that is attributed to the direction-finding site.

b. Standard deviation is computed using the formula:

$$SD = \sqrt{\frac{(BT - BO)^2}{N} - (SE)^2}.$$

(1) BT is the true bearing between the DF site and the selected check station.

(2) BO is the observed bearing of the selected check station.

(3) N is the total number of bearings, within plus or minus 8 degrees of the mean bearing, used in the computation.

(4) $(SE)^2$ is the systematic error squared.

c. The following steps outline the procedure for computing standard deviation.

Step 1. Compute the SE of a selected check station using a minimum of 200 bearings.

Step 2. Determine for each observed bearing the deviation in degrees from the true bearing. (If the true bearing on the selected check station is not known, a great circle azimuth must be computed.)

Step 3. Square each deviation.

Step 4. Add the squared deviations and divide the sum by the total number of bearings used in the computation, within plus or minus 8 degrees of the mean bearing. This step satisfies the $\frac{(BT - BO)^2}{N}$ portion of the formula.

Step 5. Square the SE obtained in step 1. Subtract the $(SE)^2$ from the number obtained in step 4.

Step 6. Compute the square root of the number obtained in step 5. The square root represents the standard deviation of the direction-finding site.

d. The following example illustrates the computation of standard deviation. To prevent a lengthy illustration, only 10 bearings are used and the following information is provided: SE = –001 degree, BT = 031 degrees. Bearings observed on the selected check station are: 029°, 025°, 032°, 029°, 034°, 032°, 030°, 028°, 034°, and 027°.

Step 1. An SE of –001 degree is provided.

Step 2. Subtract the BO from the BT.

BT		BO		Remainder
031°	–	029°	=	2°
031°	–	025°	=	6°
031°	–	032°	=	– 1°
031°	–	029°	=	2°
031°	–	034°	=	– 3°
031°	–	032°	=	– 1°
031°	–	030°	=	1°
031°	–	028°	=	3°
031°	–	034°	=	– 3°
031°	–	027°	=	4°

Step 3. Square the remainder obtained in step 2.

Remainder	Squared
2°	4
6°	36
– 1°	1
2°	4
– 3°	9
– 1°	1
1°	1
3°	9
– 3°	9
4°	16

Step 4. Add the squared deviations and divide by the total number of bearings used in the computation.

4
36
1
4
9
1
1
9
9
16
$\overline{90} / 10 = 9$

This step satisfies $\frac{(BT - BO)^2}{N}$ portion of the formula.

Step 5. Square the SE and subtract the result from the number obtained in step 4.

$\sqrt{9 - (SE)^2}$

$\sqrt{9 - (-001)^2}$

$\sqrt{9 - 1}$

$\sqrt{8}$

Step 6. Compute the square root.

$\sqrt{8}$

	2.	8	2
	√08.	00	00
	4		
48	4	00	
	3	84	
562		16	00
		11	24
		4	76

Standard deviation equals 2.82.

APPENDIX A

REFERENCES

A–1. Army Regulation (AR).

310–25	Dictionary of United States Army Terms.

A–2. Field Manual (FM).

11–60	Communications–Electronics Fundamentals: Basic Principles Direct Current.
21–26	Map Reading.

A–3. Technical Manual (TM).

11–665	CW and AM Radio Transmitters and Receivers.
11–666	Antennas and Radio Propagation.
11–681	Electrical Fundamentals (Alternating Current).
11–5825–231–25	Direction Finder Set AN/TRD–15.

A–4. USASA Regulation (USASA Reg).

(C–CC0) USASA Regulations 105–13	Standard Criteria for Supervision and Employment of USASA Direction Finding Techniques (U).

A–5. Training Film (TF).

TF 32–4106	Direction Finder Set AN/TRD–15/23 (Pattern Interpretation).

Appendix B

COMMON LOGARITHMS OF FUNCTIONS OF ANGLES IN DEGREES AND MINUTES

0°..., 180°	'	L SIN	D	L TAN	CD	L COT	L COS	'
90°..., 270°...		L COS		L COT		L TAN	L SIN	
	0	–		–		–	0.00 000	60
	1	6.46 373	30103	6.46 373	30103	3.53 627	0.00 000	59
	2	6.76 476	17609	6.76 476	17609	3.23 524	0.00 000	58
	3	6.94 085	12494	6.94 085	12494	3.05 915	0.00 000	57
	4	7.06 579	9691	7.06 579	9691	2.93 421	0.00 000	56
	5	7.16 270	7918	7.16 270	7918	2.83 730	0.00 000	55
	6	7.24 188	6694	7.24 188	6694	2.75 812	0.00 000	54
	7	7.30 882	5800	7.30 882	5800	2.69 118	0.00 000	53
	8	7.36 682	5115	7.36 682	5115	2.63 318	0.00 000	52
	9	7.41 797	4576	7.41 797	4576	2.58 203	0.00 000	51
	10	7.46 373	4139	7.46 373	4139	2.53 627	0.00 000	50
	11	7.50 512	3779	7.50 512	3779	2.49 488	0.00 000	49
	12	7.54 291	3476	7.54 291	3476	2.45 709	0.00 000	48
	13	7.57 767	3218	7.57 767	3219	2.42 233	0.00 000	47
	14	7.60 985	2997	7.60 986	2996	2.39 014	0.00 000	46
	15	7.63 982	2802	7.63 982	2803	2.36 018	0.00 000	45
	16	7.66 784	2633	7.66 785	2633	2.33 215	0.00 000	44
	17	7.69 417	2483	7.96 418	2482	2.30 582	9.99 999	43
	18	7.71 900	2348	7.71 900	2348	2.28 100	9.99 999	42
	19	7.74 248	2227	7.74 248	2228	2.25 752	9.99 999	41
	20	7.76 475	2119	7.76 476	2119	2.23 524	9.99 999	40
	21	7.78 594	2021	7.78 595	2020	2.21 405	9.99 999	39
	22	7.80 615	1930	7.80 615	1931	2.19 385	9.99 999	38
	23	7.82 545	1848	7.82 546	1848	2.17 454	9.99 999	37
	24	7.84 393	1773	7.84 394	1773	2.15 606	9.99 999	36
	25	7.86 166	1704	7.86 167	1704	2.13 833	9.99 999	35
	26	7.87 870	1639	7.87 871	1639	2.12 129	9.99 999	34
	27	7.89 509	1579	7.89 510	1579	2.10 490	9.99 999	33
	28	7.91 088	1524	7.91 089	1524	2.08 911	9.99 999	32
	29	7.92 612	1472	7.92 613	1473	2.07 387	9.99 998	31
	30	7.94 084	11424	7.94 086	1424	2.05 914	9.99 998	30
	31	7.95 508	1379	7.95 510	1379	2.04 490	9.99 998	29
	32	7.96 887	1336	7.96 889	1336	2.03 111	9.99 998	28
	33	7.98 223	1297	7.98 225	1297	2.01 775	9.99 998	27
	34	7.99 520	1259	7.99 522	1259	2.00 478	9.99 998	26
	35	8.00 779	1223	8.00 781	1223	1.99 219	9.99 998	25
	36	8.02 002	1190	8.02 004	1190	1.97 996	9.99 998	24
	37	8.03 192	1158	8.03 194	1159	1.96 806	9.99 997	23
	38	8.04 350	1128	8.04 353	1128	1.95 647	9.99 997	22
	39	8.05 478	1100	8.05 481	1100	1.94 519	9.99 997	21
	40	8.06 578	1072	8.06 581	1072	1.93 419	9.99 997	20
	41	8.07 650	1046	8.07 653	1047	1.92 347	9.99 997	19
	42	8.08 696	1022	8.08 700	1022	1.91 300	9.99 997	18
	43	8.09 718	999	8.09 722	998	1.90 278	9.99 997	17
	44	8.10 717	976	8.10 720	976	1.89 280	9.99 996	16
	45	8.11 693	954	8.11 696	955	1.88 304	9.99 996	15
	46	8.12 647	934	8.12 651	934	1.87 349	9.99 996	14
	47	8.13 581	914	8.13 585	915	1.86 415	9.99 996	13
	48	8.14 495	896	8.14 500	895	1.85 500	9.99 996	12
	49	8.15 391	877	8.15 395	878	1.84 605	9.99 996	11
	50	8.16 268	860	8.16 273	860	1.83 727	9.99 995	10
	51	8.17 128	843	8.17 133	843	1.82 867	9.99 995	9
	52	8.17 971	827	8.17 976	828	1.82 024	9.99 995	8
	53	8.18 798	812	8.18 804	812	1.81 106	9.99 995	7
	54	8.19 610	797	8.19 616	797	1.80 384	9.99 995	6
	55	8.20 407	782	8.20 413	782	1.79 587	9.99 994	5
	56	8.21 189	769	8.21 195	769	1.78 805	9.99 994	4
	57	8.21 958	755	8.21 964	756	1.78 036	9.99 994	3
	58	8.22 713	743	8.22 720	742	1.77 280	9.99 994	2
	59	8.23 456	730	8.23 462	730	1.76 538	9.99 994	1
	60	8.24 186		8.24 192		1.75 808	9.99 993	0
		L SIN	D	L TAN	CD	L COT	L COS	'
		L COS		L COT		L TAN	L SIN	

PROP. PTS.			
	3476	3218	2997
1	348	322	300
2	695	644	599
3	1043	965	899
4	1390	1287	1199
5	1738	1609	1498
	2802	2633	2483
1	280	263	248
2	560	527	497
3	841	790	745
4	1121	1053	993
5	1401	1316	1242
	2227	2021	1848
1	223	202	185
2	445	404	370
3	668	606	554
4	891	808	739
5	1113	1010	924
	1704	1579	1472
1	170	158	147
2	341	316	294
3	511	474	442
4	682	632	589
5	852	789	736
	1379	1297	1223
1	138	130	122
2	276	259	245
3	414	389	3367
4	552	519	489
5	690	649	612
	1158	1100	1046
1	116	110	105
2	232	220	209
3	347	330	314
4	463	440	418
5	579	550	523
	999	954	914
1	100	95	91
2	200	191	183
3	300	286	274
4	400	382	366
5	500	477	457
	877	843	812
1	88	84	81
2	175	169	162
3	263	253	244
4	351	337	325
5	438	422	406
	782	755	730
1	78	75	73
2	156	151	146
3	235	226	219
4	313	302	292
5	391	377	365
359°..., 179°...			
269°..., 89°...			

1°__, 181°	'	L SIN	D	L TAN	CD	L COT	L COS	
91°__, 271°__		L COS		L COT		L TAN	L SIN	
	0	8.24 186	717	8.24 192	718	1.75 808	9.99 993	60
	1	8.24 903	706	8.24 910	706	1.75 090	9.99 993	59
	2	8.25 609	695	8.25 616	696	1.74 384	9.99 993	58
	3	8.26 304	684	8.26 312	684	1.73 688	9.99 993	57
	4	8.26 988	673	8.26 996	673	1.73 004	9.99 992	56
	5	8.27 661	663	8.27 669	663	1.72 331	9.99 992	55
	6	8.28 324	653	8.28 332	654	1.71 668	9.99 992	54
	7	8.28 977	644	8.28 986	643	1.71 014	9.99 992	53
	8	8.29 621	634	8.29 629	634	1.70 371	9.99 992	52
	9	8.30 255	624	8.30 263	625	1.69 737	9.99 991	51
	10	8.30 879	616	8.30 888	617	1.69 112	9.99 991	50
	11	8.31 495	608	8.31 505	607	1.68 495	9.99 991	49
	12	8.32 103	599	8.32 112	599	1.67 888	9.99 990	48
	13	8.32 702	590	8.32 711	591	1.67 289	9.99 990	47
	14	8.33 292	583	8.33 302	584	1.66 698	9.99 990	46
	15	8.33 875	575	8.33 886	575	1.66 114	9.99 990	45
	16	8.34 450	568	8.34 461	568	1.65 539	9.99 989	44
	17	8.35 018	560	8.35 029	561	1.64 971	9.99 989	43
	18	8.35 578	553	8.35 590	553	1.64 410	9.99 989	42
	19	8.36 131	547	8.36 143	546	1.63 857	9.99 989	41
	20	8.36 678	539	8.36 689	540	1.63 311	9.99 988	40
	21	8.37 217	533	8.37 229	533	1.62 771	9.99 988	39
	22	8.37 750	526	8.37 762	527	1.62 238	9.99 988	38
	23	8.38 276	520	8.38 289	520	1.61 711	9.99 987	37
	24	8.38 796	514	8.38 809	514	1.61 191	9.99 987	36
	25	8.39 810	506	8.39 323	509	1.60 677	9.99 987	35
	26	8.39 818	502	8.39 832	502	1.60 168	9.99 986	34
	27	8.40 320	496	8.40 334	496	1.59 666	9.99 986	33
	28	8.40 816	491	8.40 830	491	1.59 170	9.99 986	32
	29	8.41 307	485	8.41 321	486	1.58 679	9.99 985	31
	30	8.41 792	480	8.41 807	480	1.58 193	9.99 985	30
	31	8.42 272	474	8.42 287	475	1.57 713	9.99 985	29
	32	8.42 746	470	8.42 762	470	1.57 238	9.99 984	28
	33	8.43 216	464	8.43 232	464	1.56 768	9.99 984	27
	34	8.43 680	459	8.43 696	460	1.56 304	9.99 984	26
	35	8.44 139	455	8.44 156	455	1.55 844	9.99 983	25
	36	8.44 594	450	8.44 611	450	1.55 389	9.99 983	24
	37	8.45 044	445	8.45 061	446	1.54 939	9.99 983	23
	38	8.45 489	441	8.45 507	441	1.54 493	9.99 982	22
	39	8.45 930	436	8.45 948	437	1.54 052	9.99 982	21
	40	8.46 366	433	8.46 385	432	1.53 615	9.99 982	20
	41	8.46 799	427	8.46 817	428	1.53 183	9.99 981	19
	42	8.47 226	424	8.47 245	424	1.52 755	9.99 981	18
	43	8.47 650	419	8.47 669	420	1.52 331	9.99 981	17
	44	8.48 069	416	8.48 089	416	1.51 911	9.99 980	16
	45	8.48 485	411	8.48 505	412	1.51 495	9.99 980	15
	46	8.48 896	408	8.48 917	408	1.51 083	9.99 979	14
	47	8.49 304	404	8.49 325	404	1.50 675	9.99 979	13
	48	8.49 708	400	8.49 729	401	1.50 271	9.99 979	12
	49	8.50 108	396	8.50 130	397	1.49 870	9.99 978	11
	50	8.50 504	393	8.50 527	393	1.49 473	9.99 978	10
	51	8.50 897	390	8.50 920	390	1.49 080	9.99 977	9
	52	8.51 287	386	8.51 310	386	1.48 690	9.99 977	8
	53	8.51 673	382	8.51 696	383	1.48 304	9.99 977	7
	54	8.52 055	379	8.52 079	380	1.47 921	9.99 976	6
	55	8.52 434	376	8.52 459	376	1.47 541	9.99 976	5
	56	8.52 810	373	8.52 835	373	1.47 165	9.99 975	4
	57	8.53 183	369	8.53 208	370	1.46 792	9.99 975	3
	58	8.53 552	367	8.53 578	367	1.46 422	9.99 974	2
	59	8.53 919	363	8.53 945	363	1.46 055	9.99 974	1
	60	8.54 282		8.54 308		1.45 692	9.99 974	0
		L SIN	D	L TAN	CD	L COT	L COS	'
		L COS		L COT		L TAN	L SIN	

PROP. PTS.			
	717	695	673
1	71.7	69.5	67.3
2	143.4	139.0	134.6
3	215.1	208.5	201.9
4	286.8	278.0	269.2
5	358.5	347.5	336.5
	653	634	616
1	65.3	63.4	61.6
2	130.6	126.8	123.2
3	195.9	190.2	184.8
4	261.2	253.6	246.4
5	326.5	317.0	308.0
	599	583	568
1	59.9	58.3	56.8
2	119.8	116.6	113.6
3	179.7	174.9	170.4
4	239.6	233.2	227.2
5	299.5	291.5	284.0
	553	539	526
1	55.3	53.9	52.6
2	110.6	107.8	105.2
3	165.9	161.7	157.8
4	221.2	215.6	210.4
5	276.5	269.5	263.0
	514	502	490
1	51.4	50.2	49
2	102.8	100.4	98
3	154.2	150.6	147
4	205.6	200.8	196
5	257.0	251.0	245
	480	470	460
1	48	47	46
2	96	94	92
3	144	141	138
4	192	188	184
5	240	235	230
	450	440	430
1	45	44	43
2	90	88	86
3	135	132	129
4	180	176	172
5	225	220	215
	420	410	400
1	42	41	40
2	84	82	80
3	126	123	120
4	168	164	160
5	210	205	200
	390	380	370
1	39	38	37
2	78	76	74
3	117	114	111
4	156	152	148
5	195	190	185
358°__, 178°__			
268°__, 88°__			

2°—, 182°— / 92°—, 272°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	8.54 282	360	8.54 308	361	1.45 692	9.99 974	60
	1	8.54 642	357	8.54 669	358	1.45 331	9.99 973	59
	2	8.54 999	355	9.55 027	355	1.44 973	9.99 973	58
	3	8.55 354	351	9.55 382	352	1.44 618	9.99 972	57
	4	8.55 705	349	8.55 734	349	1.44 266	9.99 972	56
	5	8.56 054	346	8.56 083	346	1.43 917	9.99 971	55
	6	8.56 400	343	8.56 429	344	1.43 571	9.99 971	54
	7	8.56 743	341	8.56 773	341	1.43 227	9.99 970	53
	8	8.57 084	337	8.57 114	338	1.42 886	9.99 970	52
	9	8.57 421	336	8.57 452	336	1.42 548	9.99 969	51
	10	8.57 757	332	8.57 788	333	1.42 212	9.99 969	50
	11	8.58 089	330	8.58 121	330	1.41 879	9.99 968	49
	12	8.58 419	328	8.58 451	328	1.41 549	9.99 968	48
	13	8.58 747	325	8.58 779	326	1.41 221	9.99 967	47
	14	8.59 072	323	8.59 105	323	1.40 895	9.99 967	46
	15	8.59 395	320	8.59 428	321	1.40 572	9.99 967	45
	16	8.59 715	318	8.59 749	319	1.40 251	9.99 966	44
	17	8.60 033	316	8.60 068	316	1.39 932	9.99 966	43
	18	8.60 349	313	8.60 384	314	1.39 616	9.99 965	42
	19	8.60 662	311	8.60 698	311	1.39 302	9.99 964	41
	20	8.60 973	309	8.61 009	310	1.38 991	9.99 964	40
	21	8.61 282	307	8.61 319	307	1.38 681	9.99 963	39
	22	8.61 589	305	8.61 626	305	1.38 374	9.99 963	38
	23	8.61 894	302	8.61 931	303	1.38 069	9.99 962	37
	24	8.62 196	301	8.62 234	301	1.37 766	9.99 962	36
	25	8.62 497	298	8.62 535	299	1.37 465	9.99 961	35
	26	8.62 795	296	8.62 834	297	1.37 166	9.99 961	34
	27	8.63 091	294	8.63 131	295	1.36 869	9.99 960	33
	28	8.63 385	293	8.63 426	292	1.36 574	9.99 960	32
	29	8.63 678	290	8.63 718	291	1.36 282	9.99 959	31
	30	8.63 963	288	8.64 009	289	1.35 991	9.99 959	30
	31	8.64 256	287	8.64 298	287	1.35 702	9.99 958	29
	32	8.64 543	284	8.64 585	285	1.35 415	9.99 958	28
	33	8.64 827	283	8.64 870	284	1.35 130	9.99 957	27
	34	8.65 110	281	8.65 154	281	1.34 846	9.99 956	26
	35	8.65 391	279	8.65 435	280	1.34 565	9.99 956	25
	36	8.65 670	277	8.65 715	278	1.34 285	9.99 955	24
	37	8.65 947	276	8.65 993	276	1.34 007	9.99 955	23
	38	8.66 223	274	8.66 269	274	1.33 731	9.99 954	22
	39	8.66 497	272	8.66 543	273	1.33 457	9.99 954	21
	40	8.66 769	270	8.66 816	271	1.33 184	9.99 953	20
	41	8.67 039	269	8.67 087	269	1.32 913	9.99 952	19
	42	8.67 308	267	8.67 356	268	1.32 644	9.99 952	18
	43	8.67 575	266	8.67 624	266	1.32 376	9.99 951	17
	44	8.67 841	263	8.67 890	264	1.32 110	9.99 951	16
	45	8.68 104	263	8.68 154	263	1.31 846	9.99 950	15
	46	8.68 367	260	8.68 417	261	1.31 583	9.99 949	14
	47	8.68 627	259	8.68 678	260	1.31 322	9.99 949	13
	48	8.68 886	258	8.68 938	258	1.31 062	9.99 948	12
	49	8.69 144	256	8.69 196	257	1.30 804	9.99 948	11
	50	8.69 400	254	8.69 453	255	1.30 547	9.99 947	10
	51	8.69 654	253	8.69 708	254	1.30 202	9.99 946	9
	52	8.69 907	252	8.69 962	252	1.30 038	9.99 946	8
	53	8.70 159	250	8.70 214	251	1.29 786	9.99 945	7
	54	8.70 409	249	8.70 465	249	1.29 535	9.99 944	6
	55	8.70 658	247	8.70 714	248	1.29 286	9.99 944	5
	56	8.70 905	246	8.70 962	246	1.29 038	9.99 943	4
	57	8.71 151	244	8.71 208	245	1.28 792	9.99 942	3
	58	8.71 395	243	8.71 453	244	1.28 547	9.99 942	2
	59	8.71 638	242	8.71 967	243	1.28 303	9.99 941	1
	60	8.71 880		8.71 940		1.28 060	9.99 940	0
357°—, 177°— / 267°—, 87°—		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	′

PROP. PTS.

	300	350	340
1	36	35	34
2	72	70	68
3	108	105	102
4	144	140	136
5	180	175	170
6	216	210	204
7	252	245	238
8	288	280	272
9	324	315	306

	330	320	310
1	33	32	31
2	66	64	62
3	99	96	93
4	132	128	124
5	165	160	155
6	198	192	186
7	231	224	217
8	264	256	248
9	297	288	279

	300	290	285
1	30	29	28.5
2	60	58	57.0
3	90	87	85.5
4	120	116	114.0
5	150	145	142.5
6	180	174	171.0
7	210	203	199.5
8	240	232	228.0
9	270	261	256.5

	280	275	270
1	28.0	27.5	27.0
2	56.0	55.0	54.0
3	84.0	82.5	81.0
4	112.0	110.0	108.0
5	140.0	137.5	135.0
6	168.0	165.0	162.0
7	196.0	192.5	189.0
8	224.0	220.0	216.0
9	252.0	247.5	243.0

	265	260	255
1	26.5	26.0	25.5
2	53.0	52.0	51.0
3	79.5	78.0	76.5
4	106.0	104.0	102.0
5	132.5	130.0	127.5
6	159.0	156.0	153.0
7	185.5	182.0	178.5
8	212.0	208.0	204.0
9	238.5	234.0	229.5

	250	245	240
1	25.0	24.5	24.0
2	50.0	49.0	48.0
3	75.0	73.5	72.0
4	100.0	198.0	96.0
5	125.0	122.5	120.0
6	150.0	147.0	144.0
7	175.0	171.5	168.0
8	200.0	196.0	192.0
9	225.0	220.5	216.0

3°..., 183°... / 93°..., 273°... '	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
0	8.71 880	240	8.71 940	241	1.28 060	9.99 940	60
1	8.72 120	239	8.72 181	239	1.27 819	9.99 940	59
2	8.72 359	239	8.72 420	239	1.27 580	9.99 939	58
3	8.72 597	237	8.72 659	237	1.27 341	9.99 938	57
4	8.72 834	235	8.72 896	236	1.27 104	9.99 938	56
5	8.73 069	234	8.73 132	234	1.26 868	9.99 937	55
6	8.73 303	232	8.73 366	234	1.26 634	9.99 936	54
7	8.73 535	232	8.73 600	232	1.26 400	9.99 936	53
8	8.73 767	230	8.73 832	230	1.26 168	9.99 935	52
9	8.73 997	229	8.74 063	229	1.25 937	9.99 934	51
10	8.74 226	228	8.74 292	229	1.25 708	9.99 934	50
11	8.74 454	226	8.74 521	227	1.25 479	9.99 933	49
12	8.74 680	226	8.74 748	226	1.25 252	9.99 932	48
13	8.74 906	224	8.74 974	225	1.25 026	9.99 932	47
14	8.75 130	223	8.75 199	224	1.24 801	9.99 931	46
15	8.75 353	222	8.75 423	222	1.24 577	9.99 930	45
16	8.75 575	220	8.75 645	222	1.24 355	9.99 929	44
17	8.75 795	220	8.75 867	220	1.24 133	9.99 929	43
18	8.76 015	219	8.76 087	219	1.23 913	9.99 928	42
19	8.76 234	217	8.76 306	219	1.23 694	9.99 927	41
20	8.76 451	216	8.76 525	217	1.23 475	9.99 926	40
21	8.76 667	216	8.76 742	216	1.23 258	9.99 926	39
22	8.76 883	214	8.76 958	215	1.23 042	9.99 925	38
23	8.77 097	213	8.77 173	214	1.22 827	9.99 924	37
24	8.77 610	212	8.77 387	213	1.22 613	9.99 923	36
25	8.77 522	211	8.77 600	211	1.22 400	9.99 923	35
26	8.77 733	210	8.77 811	211	1.22 189	9.99 922	34
27	8.77 943	209	8.78 022	210	1.21 978	9.99 921	33
28	8.78 152	208	8.78 232	209	1.21 768	9.99 920	32
29	8.78 360	208	8.78 441	208	1.21 559	9.99 920	31
30	8.78 568	206	8.78 649	206	1.21 351	9.99 919	30
31	8.78 774	205	8.78 855	206	1.21 145	9.99 918	29
32	8.78 979	204	8.79 061	205	1.20 939	9.99 917	28
33	8.79 138	203	8.79 266	204	1.20 734	9.99 917	27
34	8.79 386	202	8.79 470	203	1.20 530	9.99 916	26
35	8.79 588	201	8.79 673	202	1.20 327	9.99 915	25
36	8.79 789	201	8.79 875	201	1.20 125	9.99 914	24
37	8.79 990	199	8.80 076	201	1.19 924	9.99 913	23
38	8.80 189	199	8.80 277	199	1.19 723	9.99 913	22
39	8.80 388	197	8.80 476	198	1.19 524	9.99 912	21
40	8.80 585	197	8.80 674	198	1.19 326	9.99 911	20
41	8.80 782	196	8.80 872	196	1.19 128	9.99 910	19
42	8.80 978	195	8.81 068	196	1.18 932	9.99 909	18
43	8.81 173	194	8.81 264	195	1.18 736	9.99 909	17
44	8.81 367	193	8.81 459	194	1.18 541	9.99 908	16
45	8.81 560	192	8.81 653	193	1.18 347	9.99 907	15
46	8.81 752	192	8.81 846	192	1.18 154	9.99 906	14
47	8.81 944	190	8.82 038	192	1.17 962	9.99 905	13
48	8.82 134	190	8.82 230	190	1.17 770	9.99 904	12
49	8.82 324	189	8.82 420	190	1.17 580	9.99 904	11
50	8.82 513	188	8.82 610	189	1.17 390	9.99 903	10
51	8.82 701	187	8.82 799	188	1.17 201	9.99 902	9
52	8.82 888	187	8.82 987	188	1.17 013	9.99 901	8
53	8.83 075	186	8.83 175	186	1.16 825	9.99 900	7
54	8.83 261	185	8.83 361	186	1.16 639	9.99 899	6
55	8.83 446	184	8.83 547	185	1.16 453	9.99 898	5
56	8.83 630	183	8.83 732	184	1.16 268	9.99 898	4
57	8.83 813	183	8.83 916	184	1.16 084	9.99 897	3
58	8.83 996	181	8.84 100	182	1.15 900	9.99 896	2
59	8.84 177	181	8.84 282	182	1.15 718	9.99 895	1
60	8.84 358		8.84 464		1.15 536	9.99 894	0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	

PROP. PTS.

	238	234	229
1	23.8	23.4	22.9
2	47.6	46.8	45.8
3	71.4	70.2	68.7
4	95.2	93.6	91.6
5	119.0	117.0	114.5
6	142.8	140.4	137.4
7	166.6	163.8	160.3
8	190.4	187.2	183.2
9	214.2	210.6	206.1

	225	230	216
1	22.5	22.0	21.6
2	45.0	44.0	43.2
3	67.5	66.0	64.8
4	90.0	88.0	86.4
5	112.5	110.0	108.0
6	135.0	132.0	129.6
7	157.5	154.0	151.2
8	180.0	176.0	172.8
9	202.5	198.0	194.4

	212	208	204
1	21.2	20.8	20.4
2	42.4	41.6	40.8
3	63.6	62.4	61.2
4	84.8	83.2	81.6
5	106.0	104.0	102.0
6	127.2	124.8	122.4
7	148.4	145.6	142.8
8	169.6	166.4	163.2
9	190.8	187.2	183.6

	201	197	193
1	20.1	19.7	19.3
2	40.2	39.4	38.6
3	60.3	59.1	57.9
4	80.4	78.8	77.2
5	100.5	98.5	96.5
6	120.6	118.2	115.8
7	140.7	137.9	135.1
8	160.8	157.6	154.4
9	180.9	177.3	173.7

	189	185	181
1	18.9	18.5	18.1
2	37.8	37.0	36.2
3	56.7	55.5	54.3
4	75.6	74.0	72.4
5	94.5	92.5	90.5
6	113.4	111.0	108.6
7	132.3	129.5	126.7
8	151.2	148.0	144.8
9	170.1	166.5	162.9

	4	3	2	1
1	0.4	0.3	0.2	0.1
2	0.8	0.6	0.4	0.2
3	1.2	0.9	0.6	0.3
4	1.6	1.2	0.8	0.4
5	2.0	1.5	1.0	0.5
6	2.4	1.8	1.2	0.6
7	2.8	2.1	1.4	0.7
8	3.2	2.4	1.6	0.8
9	3.6	2.7	1.8	0.9

356°..., 176°...
266°..., 86°...

4°—, 184°— / 94°—, 274°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'
	0	8.84 358	181	8.84 464	182	1.15 536	9.99 894	60
	1	8.84 539	179	8.84 646	180	1.15 354	9.99 893	59
	2	8.84 718	179	8.84 826	180	1.15 174	9.99 892	58
	3	8.84 897	178	8.85 006	179	1.14 994	9.99 891	57
	4	8.85 075	177	8.85 185	178	1.14 815	9.99 891	56
	5	8.85 252	177	8.85 363	177	1.14 637	9.99 890	55
	6	8.85 429	176	8.85 540	177	1.14 460	9.99 889	54
	7	8.85 605	175	8.85 717	176	1.14 283	9.99 888	53
	8	8.85 780	175	8.85 893	176	1.14 107	9.99 887	52
	9	8.85 955	173	8.86 069	174	1.13 931	9.99 886	51
	10	8.86 128	173	8.86 243	174	1.13 757	9.99 885	50
	11	8.86 301	173	8.86 417	174	1.13 583	9.99 884	49
	12	8.86 474	171	8.86 591	172	1.13 409	9.99 883	48
	13	8.86 645	171	8.86 763	172	1.13 237	9.99 882	47
	14	8.86 816	171	8.86 935	171	1.13 065	9.99 881	46
	15	8.86 987	169	8.87 106	171	1.12 894	9.99 880	45
	16	8.87 156	169	8.87 277	170	1.12 723	9.99 879	44
	17	8.87 325	169	8.87 447	169	1.12 553	9.99 879	43
	18	8.87 494	167	8.87 616	169	1.12 384	9.99 878	42
	19	8.87 661	168	8.87 785	168	1.12 215	9.99 877	41
	20	8.87 829	166	8.87 953	167	1.12 047	9.99 876	40
	21	8.87 995	166	8.88 120	167	1.11 880	9.99 875	39
	22	8.88 161	165	8.88 287	166	1.11 713	9.99 874	38
	23	8.88 326	164	8.88 453	165	1.11 547	9.99 873	37
	24	8.88 490	164	8.88 618	165	1.11 382	9.99 872	36
	25	8.88 654	163	8.88 783	165	1.11 217	9.99 871	35
	26	8.88 817	163	8.88 948	163	1.11 052	9.99 870	34
	27	8.88 980	162	8.89 111	163	1.10 889	9.99 869	33
	28	8.89 142	162	8.89 274	163	1.10 726	9.99 868	32
	29	8.89 304	160	8.89 437	161	1.10 563	9.99 867	31
	30	8.89 464	161	8.89 598	162	1.10 402	9.99 866	30
	31	8.89 625	159	8.89 760	160	1.10 240	9.99 865	29
	32	8.89 784	159	8.89 920	160	1.10 080	9.99 864	28
	33	8.89 943	159	8.90 080	160	1.09 920	9.99 863	27
	34	8.90 102	158	8.90 240	159	1.09 760	9.99 862	26
	35	8.90 260	157	8.90 399	158	1.09 601	9.99 861	25
	36	8.90 417	157	8.90 557	158	1.09 443	9.99 860	24
	37	8.90 574	156	8.90 715	157	1.09 285	9.99 859	23
	38	8.90 730	155	8.90 872	157	1.09 128	9.99 858	22
	39	8.90 885	155	8.91 029	156	1.08 971	9.99 857	21
	40	8.91 040	155	8.91 185	155	1.08 815	9.99 856	20
	41	8.91 195	154	8.91 340	155	1.08 660	9.99 855	19
	42	8.91 349	153	8.91 495	155	1.08 505	9.99 854	18
	43	8.91 502	153	8.91 650	153	1.08 350	9.99 853	17
	44	8.91 655	152	8.91 803	154	1.08 197	9.99 852	16
	45	8.91 807	152	8.91 957	153	1.08 043	9.99 851	15
	46	8.91 959	151	8.92 110	152	1.07 890	9.99 850	14
	47	8.92 110	151	8.92 262	152	1.07 738	9.99 848	13
	48	8.92 261	150	8.92 414	151	1.07 586	9.99 847	12
	49	8.92 411	150	8.92 565	151	1.07 435	9.99 846	11
	50	8.92 561	149	8.92 716	150	1.07 284	9.99 845	10
	51	8.92 710	149	8.92 866	150	1.07 134	9.99 844	9
	52	8.92 859	148	8.92 016	149	1.06 984	9.99 843	8
	53	8.93 077	147	8.93 165	148	1.06 835	9.99 842	7
	54	8.93 154	147	8.93 313	149	1.06 687	9.99 841	6
	55	8.93 301	147	8.93 462	147	1.06 538	9.99 840	5
	56	8.93 448	146	8.93 609	147	1.06 391	9.99 839	4
	57	8.93 594	146	8.93 756	147	1.06 244	9.99 838	3
	58	8.93 740	145	8.93 903	146	1.06 097	9.99 837	2
	59	8.93 885	145	8.94 049	146	1.05 951	9.99 836	1
	60	8.94 030		8.94 195		1.05 805	9.99 834	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'

PROP. PTS.

	181	179	177
1	18.1	17.9	17.7
2	36.2	35.8	35.4
3	54.3	53.7	53.1
4	72.4	71.6	70.8
5	90.5	89.5	88.5
6	108.6	107.4	106.2
7	126.7	125.3	123.9
8	144.8	143.2	141.6
9	162.9	161.1	159.3

	175	173	171
1	17.5	17.3	17.1
2	35.0	34.6	34.2
3	52.5	51.9	51.3
4	70.0	69.2	68.4
5	87.5	86.5	85.5
6	105.0	103.8	102.6
7	122.5	121.1	119.7
8	140.0	138.4	136.8
9	157.5	155.7	153.9

	168	166	164
1	16.8	16.6	16.4
2	33.6	32.2	32.8
3	50.4	49.8	49.2
4	67.2	66.4	65.6
5	84.0	83.0	82.0
6	100.8	99.6	98.4
7	117.6	116.2	114.8
8	134.4	132.8	131.2
9	151.2	149.4	147.6

	162	159	157
1	16.2	15.9	15.7
2	32.4	31.8	31.4
3	48.6	47.7	47.1
4	64.8	63.6	62.8
5	81.0	79.5	78.5
6	97.2	95.4	94.2
7	113.4	111.3	109.9
8	129.6	127.2	125.6
9	145.8	143.1	141.3

	155	153	151
1	15.5	15.3	15.1
2	31.0	30.6	30.2
3	46.5	45.9	45.3
4	62.0	61.2	60.4
5	77.5	76.5	75.5
6	93.0	91.8	90.6
7	108.5	107.1	105.7
8	124.0	122.4	120.8
9	139.5	137.7	135.9

	149	147	1
1	14.9	14.7	0.1
2	29.8	29.4	0.2
3	44.7	44.1	0.3
4	59.6	58.8	0.4
5	74.5	73.5	0.5
6	89.4	88.2	0.6
7	104.3	102.9	0.7
8	119.2	117.6	0.8
9	134.1	132.3	0.9

355°—, 175°—

265°—, 85°—

5°..., 185°... / 95°..., 275°...	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	′
	0	8.94 030	144	8.94 195	145	1.05 805	9.99 834	60
	1	8.94 174	143	8.94 340	145	1.05 660	9.99 833	59
	2	8.94 317	144	8.94 458	145	1.05 515	9.99 832	58
	3	8.94 461	142	8.94 630	143	1.05 370	9.99 831	57
	4	8.94 603	143	8.94 773	144	1.05 227	9.99 830	56
	5	8.94 746	141	8.94 917	143	1.05 083	9.99 829	55
	6	8.94 887	142	8.95 060	142	1.04 940	9.99 828	54
	7	8.95 029	141	8.95 202	142	1.04 798	9.99 827	53
	8	8.95 170	140	8.95 344	142	1.04 656	9.99 825	52
	9	9.95 310	140	8.95 486	141	1.04 514	9.99 824	51
	10	8.95 450	139	8.95 627	140	1.04 373	9.99 823	50
	11	8.95 589	139	8.95 767	141	1.04 233	9.99 822	49
	12	8.95 728	139	8.95 908	139	1.04 092	9.99 821	48
	13	8.95 867	138	8.96 047	140	1.03 953	9.99 820	47
	14	8.95 005	138	8.96 187	138	1.03 813	9.99 819	46
	15	8.96 143	137	8.96 325	139	1.03 675	9.99 817	45
	16	8.96 280	137	8.96 464	138	1.03 536	9.99 816	44
	17	8.96 417	136	8.96 602	137	1.03 398	9.99 815	43
	18	8.96 553	136	8.96 739	138	1.03 261	9.99 814	42
	19	8.96 689	136	8.96 877	136	1.03 123	9.99 813	41
	20	8.96 825	135	8.97 013	137	1.02 987	9.99 812	40
	21	8.96 960	135	8.97 150	135	1.02 850	9.99 810	39
	22	8.97 095	134	8.97 285	136	1.02 715	9.99 809	38
	23	8.97 229	134	8.97 421	135	1.02 579	9.99 808	37
	24	8.97 363	133	8.97 556	135	1.02 444	9.99 807	36
	25	8.97 496	133	8.97 691	134	1.02 309	9.99 806	35
	26	8.97 629	133	8.97 825	134	1.02 175	9.99 804	34
	27	8.97 762	132	8.97 959	133	1.02 041	9.99 803	33
	28	8.97 894	132	8.98 002	133	1.01 908	9.99 802	32
	29	8.98 026	131	8.98 225	133	1.01 775	9.99 801	31
	30	8.98 157	131	8.98 358	132	1.01 642	9.99 800	30
	31	8.98 288	131	8.98 490	132	1.01 510	9.99 798	29
	32	8.98 419	130	8.98 622	131	1.01 378	9.99 797	28
	33	8.98 549	130	8.98 753	131	1.01 247	9.99 796	27
	34	8.98 679	129	8.98 884	131	1.01 116	9.99 795	26
	35	8.98 808	129	8.99 015	130	1.00 985	9.99 793	25
	36	8.98 937	129	8.99 145	130	1.00 855	9.99 792	24
	37	8.99 066	128	8.99 275	130	1.00 725	9.99 791	23
	38	8.99 194	128	8.99 405	129	1.00 595	9.99 790	22
	39	8.99 322	128	8.99 534	128	1.00 466	9.99 788	21
	40	8.99 450	127	8.99 662	129	1.00 338	9.99 787	20
	41	8.99 577	127	8.99 791	128	1.00 209	9.99 786	19
	42	8.99 704	126	8.99 919	127	1.00 081	9.99 785	18
	43	8.99 830	126	9.00 046	128	0.99 954	9.99 783	17
	44	8.99 956	126	9.00 174	127	0.99 826	9.99 782	16
	45	9.00 082	125	9.00 301	126	0.99 699	9.99 781	15
	46	9.00 207	125	9.00 427	126	0.99 573	9.99 780	14
	47	9.00 332	124	9.00 553	126	0.99 447	9.99 778	13
	48	9.00 456	125	9.00 679	126	0.99 321	9.99 777	12
	49	9.00 581	123	9.00 805	125	0.99 195	9.99 776	11
	50	9.00 704	124	9.00 930	125	0.99 070	9.99 775	10
	51	9.00 828	123	9.01 055	124	0.98 945	9.99 773	9
	52	9.00 951	123	9.01 179	124	0.98 821	9.99 772	8
	53	9.01 074	122	9.01 303	124	0.98 697	9.99 771	7
	54	9.01 196	122	9.01 427	123	0.98 573	9.99 769	6
	55	9.01 318	122	9.01 550	123	0.98 450	9.99 768	5
	56	9.01 440	121	9.01 673	123	0.98 327	9.99 767	4
	57	9.01 561	121	9.01 796	122	0.98 204	9.99 765	3
	58	9.01 682	121	9.01 918	122	0.98 082	9.99 764	2
	59	9.01 803	120	9.02 040	122	0.97 960	9.99 763	1
	60	9.01 923		9.02 162		00.97 838	9.99 761	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	354°..., 174°... / 264°..., 84°...

PROP. PTS.

	145	143	141	139	138	136	135	133	131
1	14.5	14.3	14.1	13.9	13.8	13.6	13.5	13.3	13.1
2	29.0	28.6	28.2	27.8	27.6	27.2	27.0	26.6	26.2
3	43.5	42.9	42.3	41.7	41.4	40.8	40.5	39.9	39.3
4	58.0	57.2	56.4	55.6	55.2	54.4	54.0	53.2	52.4
5	72.5	71.5	70.5	69.5	69.0	68.0	67.5	66.5	65.5
6	87.0	85.8	84.6	83.4	82.8	81.5	81.0	79.8	78.6
7	101.5	100.1	98.7	97.3	96.6	95.2	94.5	93.1	91.7
8	116.0	114.4	112.8	111.2	110.4	108.8	108.0	106.4	104.8
9	130.5	128.7	126.9	125.1	124.2	122.4	121.5	119.7	117.9

	129	128	126	125	123	122	121	120	1
1	12.9	12.8	12.6	12.5	12.3	12.2	12.1	12.0	0.1
2	25.8	25.6	25.2	25.0	24.6	24.4	24.2	24.0	0,2
3	38.7	38.4	37.8	37.5	36.9	36.6	36.3	36.0	0.3
4	51.6	51.2	50.4	50.0	49.2	48.8	48.4	48.0	0.4
5	64.5	64.0	63.0	62.5	61.5	61.0	60.5	60.0	0.5
6	77.4	76.8	75.6	75.0	73.8	73.2	72.6	72.0	0.6
7	90.3	89.6	88.2	87.5	86.1	85.4	84.7	84.0	0.7
8	103.2	102.4	100.8	100.0	98.4	97.6	96.8	96.0	0.8
9	116.1	115.2	113.4	112.5	110.7	109.8	108.9	108.0	0.9

6°—, 186°— / 96°—, 276°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.01 923	120	9.02 162	121	0.97 838	9.99 761	60
	1	9.02 043	120	9.02 283	121	0.97 717	9.99 760	59
	2	9.02 163	120	9.02 404	121	0.97 596	9.99 759	58
	3	9.02 283	119	9.02 525	120	0.97 475	9.99 757	57
	4	9.02 402	118	9.02 645	121	0.97 355	9.99 756	56
	5	9.02 520	119	9.02 766	119	0.97 234	9.99 755	55
	6	9.02 639	118	9.02 885	120	0.97 115	9.99 753	54
	7	9.02 757	117	9.03 005	119	0.96 995	9.99 752	53
	8	9.02 874	118	9.03 124	118	0.96 876	9.99 751	52
	9	9.02 992	117	9.03 242	119	0.96 758	9.99 749	51
	10	9.03 109	117	9.03 361	118	0.96 639	9.99 748	50
	11	9.03 226	116	9.03 479	118	0.96 521	9.99 747	49
	12	9.03 342	116	9.03 597	117	0.96 403	9.99 745	48
	13	9.03 458	116	9.03 714	118	0.96 286	9.99 744	47
	14	9.03 574	116	9.03 832	116	0.96 168	9.99 742	46
	15	9.03 690	115	9.03 948	117	0.96 052	9.99 741	45
	16	9.03 805	115	9.04 065	116	0.95 935	9.99 740	44
	17	9.03 920	114	9.04 181	116	0.95 819	9.99 738	43
	18	9.04 034	115	9.04 297	116	0.95 703	9.99 737	42
	19	9.04 149	113	9.04 413	115	0.95 587	9.99 736	41
	20	9.04 262	114	9.04 528	115	0.95 472	9.99 734	40
	21	9.04 376	114	9.04 643	115	0.95 357	9.99 733	39
	22	9.04 490	113	9.04 758	115	0.95 242	9.99 731	38
	23	9.04 603	112	9.04 873	114	0.95 127	9.99 730	37
	24	9.04 715	113	9.04 987	114	0.95 013	9.99 728	36
	25	9.04 828	112	9.05 101	113	0.94 899	9.99 727	35
	26	9.04 940	112	9.05 214	114	0.94 786	9.99 726	34
	27	9.05 052	112	9.05 328	113	0.94 672	9.99 724	33
	28	9.05 164	111	9.05 441	112	0.94 559	9.99 723	32
	29	9.05 275	111	9.05 553	113	0.94 447	9.99 721	31
	30	9.05 386	111	9.05 666	112	0.94 334	9.99 720	30
	31	9.05 497	110	9.05 778	112	0.94 222	9.99 718	29
	32	9.05 607	110	9.05 890	112	0.94 110	9.99 717	28
	33	9.05 717	110	9.06 002	111	0.93 998	9.99 716	27
	34	9.05 827	110	9.06 113	111	0.93 887	9.99 714	26
	35	9.05 937	109	9.06 224	111	0.93 776	9.99 713	25
	36	9.06 046	109	9.06 335	110	0.93 665	9.99 711	24
	37	9.06 155	109	9.06 445	111	0.93 555	9.99 710	23
	38	9.06 264	108	9.06 556	110	0.93 444	9.99 708	22
	39	9.06 372	109	9.06 666	109	0.93 334	9.99 707	21
	40	9.06 481	108	9.06 775	110	0.93 225	9.99 705	20
	41	9.06 589	107	9.06 885	109	0.93 115	9.99 704	19
	42	9.06 696	108	9.06 994	109	0.93 006	9.99 702	18
	43	9.06 804	107	9.07 103	108	0.92 897	9.99 701	17
	44	9.06 911	107	9.07 211	109	0.92 789	9.99 699	16
	45	9.07 018	106	9.07 320	108	0.92 680	9.99 698	15
	46	9.07 124	107	9.07 428	108	0.92 572	9.99 696	14
	47	9.07 231	106	9.07 536	107	0.92 464	9.99 695	13
	48	9.07 337	105	9.07 643	108	0.92 357	9.99 693	12
	49	9.07 442	106	9.07 751	107	0.92 249	9.99 692	11
	50	9.07 548	105	9.07 858	106	0.92 142	9.99 690	10
	51	9.07 653	105	9.07 964	107	0.92 036	9.99 689	9
	52	9.07 758	105	9.08 071	106	0.91 929	9.99 687	8
	53	9.07 863	105	9.08 177	106	0.91 823	9.99 686	7
	54	9.07 968	104	9.08 283	106	0.91 717	9.99 684	6
	55	9.08 072	104	9.08 389	106	0.91 611	9.99 683	5
	56	9.08 176	104	9.08 495	105	0.91 505	9.99 681	4
	57	9.08 280	103	9.08 600	105	0.91 400	9.99 680	3
	58	9.08 383	103	9.08 706	105	0.91 295	9.99 678	2
	59	9.08 486	103	9.08 810	104	0.91 190	9.99 677	1
	60	9.08 589		9.08 914		0.91 086	9.99 675	0
353°—, 173°— / 263°—, 83°—		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	

PROP. PTS.

	121	120	119
1	12.1	12.0	11.9
2	24.2	24.0	23.8
3	36.3	36.0	35.7
4	48.4	48.0	47.6
5	60.5	60.0	59.5
6	72.6	72.0	71.4
7	84.7	84.0	83.3
8	96.8	96.0	95.2
9	108.9	108.0	107.1

	118	117	116
1	11.8	11.7	11.6
2	23.6	23.4	23.2
3	35.4	35.1	34.8
4	47.2	46.8	46.4
5	59.0	58.5	58.0
6	70.8	70.2	69.6
7	82.6	81.9	81.2
8	94.4	93.6	92.8
9	106.2	105.3	104.4

	115	114	113
1	11.5	11.4	11.3
2	23.0	22.8	22.6
3	34.5	34.2	33.9
4	46.0	45.6	45.2
5	57.5	57.0	56.5
6	69.0	68.4	67.8
7	80.5	79.8	79.1
8	92.0	91.2	90.4
9	103.5	102.6	101.7

	112	111	110
1	11.2	11.1	11.0
2	22.4	22.2	22.0
3	33.6	33.3	33.0
4	44.8	44.4	44.0
5	56.0	55.5	55.0
6	67.2	66.6	66.0
7	78.4	77.7	77.0
8	89.6	88.8	88.0
9	100.8	99.9	99.0

	109	108	107
1	10.9	10.8	10.7
2	21.8	21.6	21.4
3	32.7	32.4	32.1
4	43.6	43.2	42.8
5	54.5	54.0	53.5
6	65.4	64.8	64.2
7	76.3	75.6	74.9
8	87.2	86.4	85.6
9	98.1	97.2	96.3

	106	105	104
1	10.6	10.5	10.4
2	21.2	21.0	20.8
3	31.8	31.5	31.2
4	42.4	42.0	41.6
5	53.0	52.5	52.0
6	63.6	63.0	62.4
7	74.2	73.5	72.8
8	84.8	84.0	83.2
9	95.4	94.5	93.6

7°—, 187°— / 97°—, 277°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.08 589	103	9.08 914	105	0.91 086	9.99 675	60
	1	9.08 692	103	9.09 019	104	0.90 981	9.99 674	59
	2	9.08 795	102	9.09 123	104	0.90 877	9.99 672	58
	3	9.08 897	102	9.09 227	103	0.90 773	9.99 670	57
	4	9.08 999	102	9.09 330	104	0.90 670	9.99 669	56
	5	9.09 101	101	9.09 434	103	0.90 566	9.99 667	55
	6	9.09 202	102	9.09 537	103	0.90 463	9.99 666	54
	7	9.09 304	101	9.09 640	102	0.90 360	9.99 664	53
	8	9.09 405	101	9.09 742	103	0.90 258	9.99 663	52
	9	9.09 506	100	9.09 845	102	0.90 155	9.99 661	51
	10	9.09 606	101	9.09 947	102	0.90 053	9.99 659	50
	11	9.09 707	100	9.10 049	101	0.89 951	9.99 658	49
	12	9.09 807	100	9.10 150	102	0.89 850	9.99 656	48
	13	9.09 907	99	9.10 252	101	0.89 748	9.99 655	47
	14	9.10 006	100	9.10 353	101	0.89 647	9.99 653	46
	15	9.10 106	99	9.10 454	101	0.89 546	9.99 651	45
	16	9.10 205	99	9.10 555	101	0.89 445	9.99 650	44
	17	9.10 304	98	9.10 666	100	0.89 344	9.99 648	43
	18	9.10 402	99	9.10 756	100	0.89 244	9.99 647	42
	19	9.10 501	98	9.10 856	100	0.89 144	9.99 645	41
	20	9.10 599	98	9.10 956	100	0.89 044	9.99 643	40
	21	9.10 697	98	9.11 056	99	0.88 944	9.99 642	39
	22	9.10 795	98	9.11 155	99	0.88 845	9.99 640	38
	23	9.10 893	97	9.11 254	99	0.88 746	9.99 638	37
	24	9.10 990	97	9.11 353	99	0.88 647	9.99 637	36
	25	9.11 087	97	9.11 452	99	0.88 548	9.99 635	35
	26	9.11 184	97	9.11 551	98	0.88 449	9.99 633	34
	27	9.11 281	96	9.11 649	98	0.88 351	9.99 632	33
	28	9.11 377	97	9.11 747	98	0.88 253	9.99 630	32
	29	9.11 474	96	9.11 845	98	0.88 155	9.99 629	31
	30	9.11 570	96	9.11 943	97	0.88 057	9.99 627	30
	31	9.11 666	95	9.12 040	98	0.87 960	9.99 625	29
	32	9.11 761	96	9.12 138	97	0.87 862	9.99 624	28
	33	9.11 857	95	9.12 235	97	0.87 765	9.99 622	27
	34	9.11 952	95	9.12 332	96	0.87 668	9.99 620	26
	35	9.12 047	95	9.12 428	97	0.87 572	9.99 618	25
	36	9.12 142	94	9.12 525	96	0.87 475	9.99 617	24
	37	9.12 236	95	9.12 621	96	0.87 379	9.99 615	23
	38	9.12 331	94	9.12 717	96	0.87 283	9.99 613	22
	39	9.12 425	94	9.12 813	96	0.87 187	9.99 612	21
	40	9.12 519	93	9.12 909	95	0.87 091	9.99 610	20
	41	9.12 612	94	9.13 004	95	0.86 996	9.99 608	19
	42	9.12 706	93	9.13 099	95	0.86 901	9.99 607	18
	43	9.12 799	93	9.13 194	95	0.86 806	9.99 605	17
	44	9.12 892	93	9.13 289	95	0.86 711	9.99 603	16
	45	9.12 985	93	9.13 384	94	0.86 616	9.99 601	15
	46	9.13 078	93	9.13 478	95	0.86 522	9.99 600	14
	47	9.13 171	92	9.13 573	94	0.86 427	9.99 598	13
	48	9.13 263	92	9.13 667	94	0.86 333	9.99 596	12
	49	9.13 355	92	9.13 761	93	0.86 239	9.99 595	11
	50	9.13 447	92	9.13 854	94	0.86 146	9.99 593	10
	51	9.13 539	91	9.13 948	93	0.86 052	9.99 591	9
	52	9.13 630	92	9.14 041	93	0.85 959	9.99 589	8
	53	9.13 772	91	9.14 134	93	0.85 866	9.99 588	7
	54	9.13 813	91	9.14 227	93	0.85 773	9.99 586	6
	55	9.13 904	90	9.14 320	92	0.85 680	9.99 584	5
	56	9.13 994	91	9.14 412	92	0.85 588	9.99 582	4
	57	9.14 085	90	9.14 504	93	0.85 496	9.99 581	3
	58	9.14 175	91	9.14 597	91	0.85 403	9.99 579	2
	59	9.14 266	90	9.14 688	92	0.85 312	9.99 577	1
	60	9.14 356		9.14 780		0.85 220	9.99 575	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'

352°—, 172°—
262°—, 82°—

PROP. PTS.

	105	104	103
1	10.5	10.4	10.3
2	21.0	20.8	20.6
3	31.5	31.2	30.9
4	42.0	41.6	41.2
5	52.5	52.0	51.5
6	63.0	62.4	61.8
7	73.5	72.8	72.1
8	84.0	83.2	82.4
9	94.5	93.6	92.7

	102	101	100
1	10.2	10.1	10.0
2	20.4	20.2	20.0
3	30.6	30.3	30.0
4	40.8	40.4	40.0
5	51.0	50.5	50.0
6	61.2	60.6	60.0
7	71.4	70.7	70.0
8	81.6	80.8	80.0
9	91.8	90.9	90.0

	99	98
1	9.9	9.8
2	19.8	19.6
3	29.7	29.4
4	39.6	39.2
5	49.5	49.0
6	59.4	58.8
7	69.3	68.6
8	79.2	78.4
9	89.1	88.2

	97	96	95
1	9.7	9.6	9.5
2	19.4	19.2	19.0
3	29.1	28.2	28.5
4	38.8	38.4	38.0
5	48.5	48.0	47.5
6	58.2	57.6	57.0
7	67.9	67.2	66.5
8	77.6	76.8	76.0
9	87.3	86.4	85.5

	94	93	92
1	9.4	9.3	9.2
2	18.8	18.6	18.4
3	28.2	27.9	27.6
4	37.6	37.2	36.8
5	47.0	46.5	46.0
6	56.4	55.8	55.2
7	65.8	65.1	64.4
8	75.2	74.4	73.6
9	84.6	83.7	82.8

	91	90	2
1	9.1	9.0	0.2
2	18.2	18.0	0.4
3	27.3	27.0	0.6
4	36.4	36.0	0.8
5	45.5	45.0	1.0
6	54.6	54.0	1.2
7	63.7	63.0	1.4
8	72.8	72.0	1.6
9	81.9	81.0	1.8

8°–, 188°– / 98°–, 278°–	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.14 356	89	9.14 780	92	0.85 220	9.99 575	60
	1	9.14 445	90	9.14 872	91	0.85 128	9.99 574	59
	2	9.14 535	89	9.14 963	91	0.85 037	9.99 572	58
	3	9.14 624	90	9.15 054	91	0.84 946	9.99 570	57
	4	9.14 714	89	9.15 145	91	0.84 855	9.99 568	56
	5	9.14 803	88	9.15 236	91	0.84 764	9.99 566	55
	6	9.14 891	89	9.15 327	90	0.84 673	9.99 565	54
	7	9.14 980	89	9.15 417	91	0.84 583	9.99 563	53
	8	9.15 069	88	9.15 508	90	0.84 492	9.99 561	52
	9	9.15 157	88	9.15 598	90	0.84 402	9.99 559	51
	10	9.15 245	88	9.15 688	89	0.84 312	9.99 557	50
	11	9.15 333	88	9.15 777	90	0.84 223	9.99 556	49
	12	9.15 421	87	9.15 867	89	0.84 133	9.99 554	48
	13	9.15 508	88	9.15 956	90	0.84 044	9.99 552	47
	14	9.15 596	87	9.16 046	89	0.83 954	9.99 550	46
	15	9.15 683	87	9.16 135	89	0.83 865	9.99 548	45
	16	9.15 770	87	9.16 224	88	0.83 776	9.99 546	44
	17	9.15 857	87	9.16 312	89	0.83 688	9.99 545	43
	18	9.15 944	86	9.16 401	88	0.83 599	9.99 543	42
	19	9.16 030	86	9.16 489	88	0.83 511	9.99 541	41
	20	9.16 116	87	9.16 577	88	0.83 423	9.99 539	40
	21	9.16 203	86	9.16 665	88	0.83 335	9.99 537	39
	22	9.16 289	85	9.16 753	88	0.83 247	9.99 535	38
	23	9.16 374	86	9.16 841	87	0.83 159	9.99 533	37
	24	9.16 460	85	9.16 928	88	0.83 072	9.99 532	36
	25	9.16 545	86	9.17 016	87	0.82 984	9.99 530	35
	26	9.16 631	85	9.17 103	87	0.82 897	9.99 528	34
	27	9.16 716	85	9.17 190	87	0.82 810	9.99 526	33
	28	9.16 801	85	9.17 277	86	0.82 723	9.99 524	32
	29	9.16 886	84	9.17 363	87	0.82 637	9.99 522	31
	30	9.16 970	85	9.17 450	86	0.82 550	9.99 520	30
	31	9.17 055	84	9.17 536	86	0.82 464	9.99 518	29
	32	9.17 139	84	9.17 622	86	0.82 378	9.99 517	28
	33	9.17 223	84	9.17 708	86	0.82 292	9.99 515	27
	34	9.17 307	84	9.17 794	86	0.82 206	9.99 513	26
	35	9.17 391	83	9.17 880	85	0.82 120	9.99 511	25
	36	9.17 474	84	9.17 965	86	0.82 035	9.99 509	24
	37	9.17 558	83	9.18 051	85	0.81 949	9.99 507	23
	38	9.17 641	83	9.18 136	85	0.81 864	9.99 505	22
	39	9.17 724	83	9.18 221	85	0.81 779	9.99 503	21
	40	9.17 807	83	9.18 306	85	0.81 694	9.99 501	20
	41	9.17 890	83	9.18 391	84	0.81 609	9.99 499	19
	42	9.17 973	82	9.18 475	85	0.81 525	9.99 497	18
	43	9.18 055	82	9.18 560	84	0.81 440	9.99 495	17
	44	9.18 137	83	9.18 644	84	0.81 356	9.99 494	16
	45	9.18 220	82	9.18 728	84	0.81 272	9.99 492	15
	46	9.18 302	81	9.18 812	84	0.81 188	9.99 490	14
	47	9.18 383	82	9.18 869	83	0.81 104	9.99 488	13
	48	9.18 465	82	9.18 979	84	0.81 021	9.99 486	12
	49	9.18 547	81	9.19 063	83	0.80 937	9.99 484	11
	50	9.18 628	81	9.19 146	83	0.80 854	9.99 482	10
	51	9.18 709	81	9.19 229	83	0.80 771	9.99 480	9
	52	9.18 790	81	9.19 342	83	0.80 688	9.99 478	8
	53	9.18 871	81	9.19 395	83	0.80 605	9.99 476	7
	54	9.18 952	81	9.19 478	83	0.80 522	9.99 474	6
	55	9.19 033	80	9.19 561	82	0.80 439	9.99 472	5
	56	9.19 113	80	9.19 643	82	0.80 357	9.99 470	4
	57	9.19 193	80	9.19 725	82	0.80 275	9.99 468	3
	58	9.19 273	80	9.19 807	82	0.80 193	9.99 466	2
	59	9.19 353	80	9.19 889	82	0.80 111	9.99 464	1
	60	9.19 433		9.19 971		0.80 029	9.99 462	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / LL SIN	′

PROP. PTS.

	92	91	90
1	9.2	9.1	9.0
2	18.4	18.2	18.0
3	27.6	27.3	27.0
4	36.8	36.4	36.0
5	46.0	45.5	45.0
6	55.2	54.6	54.0
7	64.4	63.7	63.0
8	73.6	72.8	72.0
9	82.8	81.9	81.0

	89	88
1	8.9	8.8
2	17.8	17.6
3	26.7	26.4
4	35.6	35.2
5	44.5	44.0
6	53.4	52.8
7	62.3	61.6
8	71.2	70.4
9	80.1	79.2

	87	86
1	8.7	8.6
2	17.4	17.2
3	26.1	25.8
4	34.8	34.4
5	43.5	43.0
6	52.2	51.6
7	60.9	60.2
8	69.6	68.8
9	78.3	77.4

	85	84
1	8.5	8.4
2	17.0	16.8
3	25.5	25.2
4	34.0	33.6
5	42.5	42.0
6	51.0	50.4
7	59.5	58.8
8	68.0	67.2
9	76.5	75.6

	83	82
1	8.3	8.2
2	16.6	16.4
3	24.9	24.6
4	33.2	32.8
5	41.5	41.0
6	49.8	49.2
7	58.1	57.4
8	66.4	65.6
9	74.7	73.8

	81	80	2
1	8.1	8.0	0.2
2	16.2	16.0	0.4
3	24.3	24.0	0.6
4	32.4	32.0	0.8
5	40.5	40.0	1.0
6	48.6	48.0	1.2
7	56.7	56.0	1.4
8	64.8	64.0	1.6
9	72.9	72.0	1.8

351°–, 171°–
261°–, 81°–

9°__, 189°__ / 99°__, 279°__	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'
	0	9.19 433	80	9.19 971	82	0.80 029	9.99 462	60
	1	9.19 513	79	9.20 053	81	0.79 947	9.99 460	59
	2	9.19 592	80	9.20 134	82	0.79 866	9.99 458	58
	3	9.19 672	79	9.20 216	81	0.79 784	9.99 456	57
	4	9.19 751	79	9.20 297	81	0.79 703	9.99 454	56
	5	9.19 830	79	9.20 378	81	0.79 622	9.99 452	55
	6	9.19 909	79	9.20 459	81	0.79 541	9.99 450	54
	7	9.19 988	79	9.20 540	81	0.79 460	9.99 448	53
	8	9.20 067	78	9.20 621	80	0.79 379	9.99 446	52
	9	9.20 145	78	9.20 701	81	0.79 299	9.99 444	51
	10	9.20 223	79	9.20 782	80	0.79 218	9.99 442	50
	11	9.20 302	78	9.20 862	80	0.79 138	9.99 440	49
	12	9.20 380	78	9.20 942	80	0.79 058	9.99 438	48
	13	9.20 458	77	9.21 022	80	0.78 978	9.99 436	47
	14	9.20 535	78	9.21 102	80	0.78 898	9.99 434	46
	15	9.20 613	78	9.21 182	79	0.78 818	9.99 432	45
	16	9.20 691	77	9.21 261	80	0.78 739	9.99 429	44
	17	9.20 768	77	9.21 341	79	0.78 659	9.99 427	43
	18	9.20 845	77	9.21 420	79	0.78 580	9.99 425	42
	19	9.20 922	77	9.21 499	79	0.78 501	9.99 423	41
	20	9.20 999	77	9.21 578	79	0.78 422	9.99 421	40
	21	9.21 076	77	9.21 657	79	0.78 343	9.99 419	39
	22	9.21 153	76	9.21 736	78	0.78 264	9.99 417	38
	23	9.21 229	77	9.21 814	79	0.78 186	9.99 415	37
	24	9.21 306	76	9.21 893	78	0.78 107	9.99 413	36
	25	9.21 382	76	9.21 971	78	0.78 029	9.99 411	35
	26	9.21 458	76	9.22 049	78	0.77 951	9.99 409	34
	27	9.21 534	76	9.22 127	78	0.77 873	9.99 407	33
	28	9.21 610	75	9.22 205	78	0.77 795	9.99 404	32
	29	9.21 685	76	9.22 283	78	0.77 717	9.99 402	31
	30	9.21 761	75	9.22 361	77	0.77 639	9.99 400	30
	31	9.21 836	76	9.22 438	78	0.77 562	9.99 398	29
	32	9.21 912	75	9.22 516	77	0.77 484	9.99 396	28
	33	9.21 987	75	9.22 593	77	0.77 407	9.99 394	27
	34	9.22 062	75	9.22 670	77	0.77 330	9.99 392	26
	35	9.22 137	74	9.22 747	77	0.77 253	9.99 390	25
	36	9.22 211	75	9.22 824	77	0.77 176	9.99 388	24
	37	9.22 286	75	9.22 901	76	0.77 099	9.99 385	23
	38	9.22 361	74	9.22 977	77	0.77 023	9.99 383	22
	39	9.22 435	74	9.23 054	76	0.76 945	9.99 381	21
	40	9.22 509	74	9.23 130	76	0.76 870	9.99 379	20
	41	9.22 583	74	9.23 206	77	0.76 794	9.99 377	19
	42	9.22 657	74	9.23 283	76	0.76 717	9.99 375	18
	43	9.22 731	74	9.23 359	76	0.76 641	9.99 372	17
	44	9.22 805	73	9.23 435	75	0.76 565	9.99 370	16
	45	9.22 878	74	9.23 510	76	0.76 490	9.99 368	15
	46	9.22 952	73	9.23 586	75	0.76 414	9.99 366	14
	47	9.23 025	73	9.23 661	76	0.76 339	9.99 364	13
	48	9.23 098	73	9.23 737	75	0.76 263	9.99 362	12
	49	9.23 171	73	9.23 812	75	0.76 188	9.99 359	11
	50	9.23 244	73	9.23 887	75	0.76 113	9.99 357	10
	51	9.23 317	73	9.23 962	75	0.76 038	9.99 355	9
	52	9.23 390	72	9.24 037	75	0.75 963	9.99 353	8
	53	9.23 462	73	9.24 112	74	0.75 888	9.99 351	7
	54	9.23 535	72	9.24 186	75	0.75 814	9.99 348	6
	55	9.23 607	72	9.24 261	74	0.75 739	9.99 346	5
	56	9.23 679	73	9.24 335	75	0.75 665	9.99 344	4
	57	9.23 752	71	9.24 410	74	0.75 590	9.99 342	3
	58	9.23 823	72	9.24 484	74	0.75 516	9.99 340	2
	59	9.23 895	72	9.24 558	74	0.75 442	9.99 337	1
	60	9.23 967		9.24 632		0.75 368	9.99 335	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'

PROP. PTS.

	82	81	80
1	8.2	8.1	8.0
2	16.4	16.2	16.0
3	24.6	24.3	24.0
4	32.8	32.4	32.0
5	41.0	40.5	40.0
6	49.2	48.6	48.0
7	57.4	56.7	56.0
8	65.6	64.8	64.0
9	73.8	72.9	72.0

	79	78
1	7.9	7.8
2	15.8	15.6
3	23.7	23.4
4	31.6	31.2
5	39.5	39.0
6	47.4	46.8
7	55.3	54.6
8	63.2	62.4
9	71.1	70.2

	77	76
1	7.7	7.6
2	15.4	15.2
3	23.1	22.8
4	30.8	30.4
5	38.5	38.0
6	46.2	45.6
7	53.9	53.2
8	61.6	60.8
9	69.3	68.4

	75	74
1	7.5	7.4
2	15.0	14.8
3	22.5	22.2
4	30.0	29.6
5	37.5	37.0
6	45.0	44.4
7	52.5	51.8
8	60.0	59.2
9	67.5	66.6

	73	72
1	7.3	7.2
2	14.6	14.4
3	21.9	21.6
4	29.2	28.8
5	36.5	36.0
6	43.8	43.2
7	51.1	50.4
8	58.4	57.6
9	65.7	64.8

	71	3	2
1	7.1	0.3	0.2
2	14.2	0.6	0.4
3	21.3	0.9	0.6
4	28.4	1.2	0.8
5	35.5	1.5	1.0
6	42.6	1.8	1.2
7	49.7	2.1	1.4
8	56.8	2.4	1.6
9	63.9	2.7	1.8

350°__, 170°__

260°__, 80°__

10°…, 190°… / 100°…, 280°…	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039	71	9.24 706	73	0.75 294	9.99 333	59
	2	9.24 110	71	9.24 779	74	0.75 221	9.99 331	58
	3	9.24 181	72	9.24 853	73	0.75 147	9.99 328	57
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	56
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	55
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	70	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	71	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	70	9.25 292	73	0.74 708	9.99 315	51
	10	9.24 677	71	9.25 365	72	0.74 635	9.99 313	50
	11	9.24 748	70	9.25 437	73	0.74 563	9.99 310	49
	12	9.24 818	70	9.25 510	72	0.74 490	9.99 308	48
	13	9.24 888	70	9.25 582	73	0.74 418	9.99 306	47
	14	9.24 958	70	9.25 655	72	0.74 345	9.99 304	46
	15	9.25 028	70	9.25 727	72	0.74 273	9.99 301	45
	16	9.25 098	70	9.25 799	72	0.74 201	9.99 299	44
	17	9.25 168	69	9.25 871	72	0.74 129	9.99 297	43
	18	9.25 237	70	9.25 943	72	0.74 057	9.99 294	42
	19	9.25 307	69	9.26 015	71	0.73 985	9.99 292	41
	20	9.25 376	69	9.26 086	72	0.73 914	9.99 290	40
	21	9.25 445	69	9.26 158	71	0.73 842	9.99 288	39
	22	9.25 514	69	9.26 229	72	0.73 771	9.99 285	38
	23	9.25 583	69	9.26 301	71	0.73 699	9.99 283	37
	24	9.25 652	69	9.26 372	71	0.73 628	9.99 281	36
	25	9.25 721	69	9.26 443	71	0.73 557	9.99 278	35
	26	9.25 790	68	9.26 514	71	0.73 486	9.99 276	34
	27	9.25 858	69	9.26 585	70	0.73 415	9.99 274	33
	28	9.25 927	68	9.26 655	71	0.73 345	9.99 271	32
	29	9.25 995	68	9.26 726	71	0.73 274	9.99 269	31
	30	9.26 063	68	9.26 797	70	0.73 203	9.99 267	30
	31	9.26 131	68	9.26 867	70	0.73 133	9.99 264	29
	32	9.26 199	68	9.26 937	71	0.73 063	9.99 262	28
	33	9.26 267	68	9.27 008	70	0.72 992	9.99 260	27
	34	9.26 335	68	9.27 078	70	0.72 922	9.99 257	26
	35	9.26 403	67	9.27 148	70	0.72 852	9.99 255	25
	36	9.26 470	68	9.27 218	70	0.72 782	9.99 252	24
	37	9.26 538	67	9.27 288	69	0.72 712	9.99 250	23
	38	9.26 605	67	9.27 357	70	0.72 643	9.99 248	22
	39	9.26 672	67	9.27 427	69	0.72 573	9.99 245	21
	40	9.26 739	67	9.27 496	70	0.72 504	9.99 243	20
	41	9.26 806	67	9.27 566	69	0.72 434	9.99 241	19
	42	9.26 873	67	9.27 635	69	0.72 365	9.99 238	18
	43	9.26 940	67	9.27 704	69	0.72 296	9.99 236	17
	44	9.27 007	66	9.27 773	69	0.72 227	9.99 233	16
	45	9.27 073	67	9.27 842	69	0.72 158	9.99 231	15
	46	9.27 140	66	9.27 911	69	0.72 089	9.99 229	14
	47	9.27 206	67	9.27 980	69	0.72 020	9.99 226	13
	48	9.27 273	66	9.28 049	68	0.71 951	9.99 224	12
	49	9.27 339	66	9.28 117	69	0.71 883	9.99 221	11
	50	9.27 405	66	9.28 186	68	0.71 814	9.99 219	10
	51	9.27 471	66	9.28 254	69	0.71 746	9.99 217	9
	52	9.27 537	65	9.28 323	68	0.71 677	9.99 214	8
	53	9.27 602	66	9.28 391	68	0.71 609	9.99 212	7
	54	9.27 668	66	9.28 459	68	0.71 541	9.99 209	6
	55	9.27 734	65	9.28 527	68	0.71 473	9.99 207	5
	56	9.27 799	65	9.28 595	67	0.71 405	9.99 204	4
	57	9.27 864	66	9.28 662	68	0.71 338	9.99 202	3
	58	9.27 930	65	9.28 730	68	0.71 270	9.99 200	2
	59	9.27 995	65	9.28 798	67	0.71 202	9.99 197	1
	60	9.28 060		9.28 865		0.71 135	9.99 195	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	′

349°…, 169°… / 259°…, 79°…

PROP. PTS.

	74	73	72	71	70	69	68	67	66	65	3	2
1	7.4	7.3	7.2	7.1	7.0	6.9	6.8	6.7	6.6	6.5	0.3	0.2
2	14.8	14.6	14.4	14.2	14.0	13.8	13.6	13.4	13.2	13.0	0.6	0.4
3	22.2	21.9	21.6	21.3	21.0	20.7	20.4	20.1	19.8	19.5	0.9	0.6
4	29.6	29.2	28.8	28.4	28.0	27.6	27.2	26.8	26.4	26.0	1.2	0.8
5	37.0	36.5	36.0	35.5	35.0	34.5	34.0	33.5	33.0	32.5	1.5	1.0
6	44.4	43.8	43.2	42.6	42.0	41.4	40.8	40.2	39.6	39.0	1.8	1.2
7	51.8	51.1	50.4	49.7	49.0	48.3	47.6	46.9	46.2	45.5	2.1	1.4
8	59.2	58.4	57.6	56.8	56.0	55.2	54.4	53.6	52.8	52.0	2.4	1.6
9	66.6	65.7	64.8	63.9	63.0	62.1	61.2	60.3	59.4	58.5	2.7	1.8

11°..., 191°... / 101°..., 261°...	'	L SIN	D	L TAN	CD	L COT	L COS	'
		L COS		L COT		L TAN	L SIN	
	0	9.28 060	65	9.28 865	68	0.71 135	9.99 195	60
	1	9.28 125	65	9.28 933	67	0.71 067	9.99 192	59
	2	9.28 190	64	9.29 000	67	0.71 000	9.99 190	58
	3	9.28 294	65	9.29 867	67	0.70 933	9.99 187	57
	4	9.28 319	65	9.29 134	67	0.70 866	9.99 185	56
	5	9.28 384	64	9.29 201	67	0.70 799	9.99 182	55
	6	9.28 448	64	9.29 268	67	0.70 732	9.99 180	54
	7	9.28 512	65	9.29 335	67	0.70 665	9.99 177	53
	8	9.28 577	64	9.29 402	66	0.70 598	9.99 175	52
	9	9.28 641	64	9.29 468	67	0.70 532	9.99 172	51
	10	9.28 705	64	9.29 535	66	0.70 465	9.99 170	50
	11	9.28 769	64	9.29 601	67	0.70 399	9.99 167	49
	12	9.28 833	63	9.29 668	66	0.70 332	9.99 165	48
	13	9.28 896	64	9.29 734	66	0.70 266	9.99 162	47
	14	9.28 960	64	9.29 800	66	0.70 200	9.99 160	46
	15	9.29 024	63	9.29 866	66	0.70 134	9.99 157	45
	16	9.29 087	63	9.29 932	66	0.70 068	9.99 155	44
	17	9.29 150	64	9.29 998	66	0.70 002	9.99 152	43
	18	9.29 214	63	9.30 064	66	0.69 936	9.99 150	42
	19	9.29 277	63	9.30 130	65	0.69 870	9.99 147	41
	20	9.29 340	63	9.30 195	66	0.69 805	9.99 145	40
	21	9.29 403	63	9.30 261	65	0.69 739	9.99 142	39
	22	9.29 466	63	9.30 326	65	0.69 674	9.99 140	38
	23	9.29 529	62	9.30 391	66	0.69 609	9.99 137	37
	24	9.29 591	63	9.30 457	65	0.69 543	9.99 135	36
	25	9.29 654	62	9.30 522	65	0.69 478	9.99 132	35
	26	9.29 716	63	9.30 587	65	0.69 413	9.99 130	34
	27	9.29 779	62	9.30 652	65	0.69 348	9.99 127	33
	28	9.29 841	62	9.30 717	65	0.69 283	9.99 124	32
	29	9.29 903	63	9.30 782	64	0.69 218	9.99 122	31
	30	9.29 966	62	9.30 846	65	0.69 154	9.99 119	30
	31	9.30 028	62	9.30 911	64	0.69 089	9.99 117	29
	32	9.30 090	61	9.30 975	65	0.69 025	9.99 114	28
	33	9.30 151	62	9.31 040	64	0.68 960	9.99 112	27
	34	9.30 213	62	9.31 104	64	0.68 896	9.99 109	26
	35	9.30 275	61	9.31 168	65	0.68 832	9.99 106	25
	36	9.30 336	62	9.31 233	64	0.68 767	9.99 104	24
	37	9.30 398	61	9.31 297	64	0.68 703	9.99 101	23
	38	9.30 459	62	9.31 361	64	0.68 639	9.99 099	22
	39	9.30 521	61	9.31 425	64	0.68 575	9.99 099	21
	40	9.30 582	61	9.31 489	63	0.68 511	9.99 093	20
	41	9.30 643	61	9.31 552	64	0.68 448	9.99 091	19
	42	9.30 704	61	9.31 616	63	0.68 384	9.99 088	18
	43	9.30 765	61	9.31 679	64	0.68 321	9.99 086	17
	44	9.30 826	61	9.31 743	63	0.68 257	9.99 083	16
	45	9.30 887	60	9.31 806	64	0.68 194	9.99 080	15
	46	9.30 947	61	9.31 870	63	0.68 130	9.99 078	14
	47	9.31 008	60	9.31 933	63	0.68 067	9.99 075	13
	48	9.31 068	61	9.31 996	63	0.68 004	9.99 072	12
	49	9.31 129	60	9.32 059	63	0.67 941	9.99 070	11
	50	9.31 189	61	9.32 122	63	0.67 878	9.99 067	10
	51	9.31 250	60	9.32 185	63	0.67 815	9.99 064	9
	52	9.31 310	60	9.32 248	63	0.67 752	9.99 062	8
	53	9.31 370	60	9.32 311	62	0.67 689	9.99 059	7
	54	9.31 430	60	9.32 373	63	0.67 627	9.99 056	6
	55	9.31 490	59	9.32 436	62	0.67 564	9.99 054	5
	56	9.31 549	60	9.32 498	63	0.67 502	9.99 051	4
	57	9.31 609	60	9.32 561	62	0.67 439	9.99 048	3
	58	9.31 669	59	9.32 623	62	0.67 377	9.99 046	2
	59	9.31 728	60	9.32 685	62	0.67 315	9.99 043	1
	60	9.31 788		9.32 747		0.67 253	9.99 040	0
		L SIN	D	L TAN	CD	L COT	L COS	'
		L COS		L COT		L TAN	L SIN	

PROP. PTS.

	68	67	66	65	64	63	62	61	60	59	3	2
1	6.8	6.7	6.6	6.5	6.4	6.3	6.2	6.1	6.0	5.9	0.3	0.2
2	13.6	13.4	13.2	13.0	12.8	12.6	12.4	12.2	12.0	11.8	0.6	0.4
3	20.4	20.1	19.8	19.5	19.2	18.9	18.6	18.3	18.0	17.7	0.9	0.6
4	27.2	26.8	26.4	26.0	25.6	25.2	24.8	24.4	24.0	23.6	1.2	0.8
5	34.0	33.5	33.0	32.5	32.0	31.5	31.0	30.5	30.0	29.5	1.5	1.0
6	40.8	40.2	39.6	39.0	38.4	37.8	37.2	36.6	36.0	35.4	1.8	1.2
7	47.6	46.9	46.2	45.5	44.8	44.1	43.4	42.7	42.0	41.3	2.1	1.4
8	54.4	53.6	52.8	52.0	51.2	50.4	49.6	48.8	48.0	47.2	2.4	1.6
9	61.2	60.3	59.4	58.5	57.5	56.7	55.8	54.9	54.0	53.1	2.7	1.8

348°..., 168°...
258°..., 78°...

12°..., 192°... / 102°..., 282°...	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.31 788	59	9.32 747	63	0.67 253	9.99 040	60
	1	9.31 847	60	9.32 810	62	0.67 190	9.99 038	59
	2	9.31 907	59	9.32 872	61	0.67 128	9.99 035	58
	3	9.31 966	59	9.32 933	62	0.67 067	9.99 032	57
	4	9.32 025	59	9.32 995	62	0.67 005	9.99 030	56
	5	9.32 084	59	9.33 057	62	0.66 943	9.99 027	55
	6	9.32 143	59	9.33 119	61	0.66 881	9.99 024	54
	7	9.32 202	59	9.33 180	62	0.66 820	9.99 022	53
	8	9.32 261	58	9.33 242	61	0.66 758	9.99 019	52
	9	9.32 319	59	9.33 303	62	0.66 697	9.99 016	51
	10	9.32 378	59	9.33 365	61	0.66 635	9.99 013	50
	11	9.32 437	58	9.33 426	61	0.66 574	9.99 011	49
	12	9.32 495	58	9.33 487	61	0.66 513	9.99 008	48
	13	9.32 553	59	9.33 548	61	0.66 452	9.99 005	47
	14	9.32 612	58	9.33 609	61	0.66 391	9.99 002	46
	15	9.32 670	58	9.33 670	61	0.66 330	9.99 000	45
	16	9.32 728	58	9.33 731	61	0.66 269	9.98 997	44
	17	9.32 786	58	9.33 792	61	0.66 208	9.98 994	43
	18	9.32 844	58	9.33 853	60	0.66 147	9.98 991	42
	19	9.32 902	58	9.33 913	61	0.66 087	9.98 989	41
	20	9.32 960	58	9.33 974	60	0.66 026	9.98 986	40
	21	9.33 018	57	9.34 034	61	0.65 966	9.98 983	39
	22	9.33 075	58	9.34 095	60	0.65 905	9.98 980	38
	23	9.33 133	57	9.34 155	60	0.65 845	9.98 978	37
	24	9.33 190	58	9.34 215	61	0.65 785	9.98 975	36
	25	9.33 248	57	9.34 276	60	0.65 724	9.98 972	35
	26	9.33 305	57	9.34 336	60	0.65 664	9.98 969	34
	27	9.33 362	58	9.34 396	60	0.65 604	9.98 967	33
	28	9.33 420	57	9.34 456	60	0.65 544	9.98 964	32
	29	9.33 477	57	9.34 516	60	0.65 484	9.98 961	31
	30	9.33 534	57	9.34 576	59	0.65 424	9.98 958	30
	31	9.33 591	56	9.34 635	60	0.65 365	9.98 955	29
	32	9.33 647	57	9.34 695	60	0.65 305	9.98 953	28
	33	9.33 704	57	9.34 755	59	0.65 245	9.98 950	27
	34	9.33 761	57	9.34 814	60	0.65 186	9.98 947	26
	35	9.33 818	56	9.34 874	59	0.65 126	9.98 944	25
	36	9.33 874	57	9.34 933	59	0.65 067	9.98 941	24
	37	9.33 931	56	9.34 992	59	0.65 008	9.98 938	23
	38	9.33 987	56	9.35 051	60	0.64 949	9.98 936	22
	39	9.34 043	57	9.35 111	59	0.64 889	9.98 933	21
	40	9.34 100	56	9.35 170	59	0.64 830	9.98 930	20
	41	9.34 156	56	9.35 229	59	0.64 771	9.98 927	19
	42	9.34 212	56	9.35 288	59	0.64 712	9.98 924	18
	43	9.34 268	56	9.35 347	58	0.64 653	9.98 921	17
	44	9.34 324	56	9.35 405	59	0.64 595	9.98 919	16
	45	9.34 380	56	9.35 464	59	0.64 536	9.98 916	15
	46	9.34 436	55	9.35 523	58	0.64 477	9.98 913	14
	47	9.34 491	56	9.35 581	59	0.64 419	9.98 910	13
	48	9.34 547	55	9.35 640	58	0.64 360	9.98 907	12
	49	9.34 602	56	9.35 698	59	0.64 302	9.98 904	11
	50	9.34 658	55	9.35 757	58	0.64 243	9.98 901	10
	51	9.34 713	56	9.35 815	58	0.64 185	9.98 898	9
	52	9.34 769	55	9.35 873	58	0.64 127	9.98 896	8
	53	9.34 824	55	9.35 931	58	0.64 069	9.98 893	7
	54	9.34 879	55	9.35 989	58	0.64 011	9.98 890	6
	55	9.34 934	55	9.36 047	58	0.63 953	9.98 887	5
	56	9.34 989	55	9.36 105	58	0.63 895	9.98 884	4
	57	9.35 044	55	9.36 163	58	0.63 837	9.98 881	3
	58	9.35 099	55	9.36 221	58	0.63 779	9.98 878	2
	59	9.35 154	55	9.36 279	57	0.63 721	9.98 875	1
	60	9.35 209		9.36 336		0.63 664	9.98 872	0

PROP. PTS.

	63	62	61	60	59	58	57	56	55	3	2
1	6.3	6.2	6.1	6.0	5.9	5.8	5.7	5.6	5.5	0.3	0.2
2	12.6	12.4	12.2	12.0	11.8	11.6	11.4	11.2	11.0	0.6	0.4
3	18.9	18.6	18.3	18.0	17.7	17.4	17.1	16.8	16.5	0.9	0.6
4	25.2	24.8	24.4	24.0	23.6	23.2	22.8	22.4	22.0	1.2	0.8
5	31.5	31.0	30.5	30.0	29.5	29.0	28.5	28.0	27.5	1.5	1.0
6	37.8	37.2	36.6	36.0	35.4	34.8	34.2	33.6	33.0	1.8	1.2
7	44.1	43.4	42.7	42.0	41.3	40.6	39.9	39.2	38.5	2.1	1.4
8	50.4	49.6	48.8	48.0	47.2	46.4	45.6	44.8	44.0	2.4	1.6
9	56.7	55.8	54.9	54.0	53.1	52.2	51.3	50.4	49.5	2.7	1.8

	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	'	347°..., 167°... / 257°..., 77°...

13°—, 193°— / 103°—, 283°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	′
	0	9.35 209	54	9.36 336	58	0.63 664	9.98 872	60
	1	9.35 263	55	9.36 394	58	0.63 606	9.98 869	59
	2	9.35 318	55	9.36 452	57	0.63 548	9.98 867	58
	3	9.35 373	54	9.36 509	57	0.63 491	9.98 864	57
	4	9.35 427	54	9.36 566	58	0.63 434	9.98 861	56
	5	9.35 481	55	9.36 624	57	0.63 376	9.98 858	55
	6	9.35 536	54	9.36 681	57	0.63 319	9.98 855	54
	7	9.35 590	54	9.36 738	57	0.63 262	9.98 852	53
	8	9.35 644	54	9.36 795	57	0.63 205	9.98 849	52
	9	9.35 698	54	9.36 852	57	0.63 148	9.98 846	51
	10	9.35 752	54	9.36 909	57	0.63 091	9.98 843	50
	11	9.35 806	54	9.36 966	57	0.63 034	9.98 840	49
	12	9.35 860	54	9.37 023	57	0.62 977	9.98 837	48
	13	9.35 914	54	9.37 080	57	0.62 920	9.98 834	47
	14	9.35 968	54	9.37 137	56	0.62 863	9.98 831	46
	15	9.36 022	53	9.37 193	57	0.62 807	9.98 828	45
	16	9.36 075	54	9.37 250	56	0.62 750	9.98 825	44
	17	9.36 129	53	9.37 306	57	0.62 694	9.98 822	43
	18	9.36 182	54	9.37 363	56	0.62 637	9.98 819	42
	19	9.36 236	53	9.37 419	57	0.62 581	9.98 816	41
	20	9.36 289	53	9.37 476	56	0.62 524	9.98 813	40
	21	9.36 342	53	9.37 532	56	0.62 468	9.98 810	39
	22	9.36 395	54	9.37 588	56	0.62 412	9.98 807	38
	23	9.36 449	53	9.37 644	56	0.62 356	9.98 804	37
	24	9.36 502	53	9.37 700	56	0.62 300	9.98 801	36
	25	9.36 555	53	9.37 756	56	0.62 244	9.98 798	35
	26	9.36 608	52	9.37 812	56	0.62 188	9.98 795	34
	27	9.36 660	53	9.37 868	56	0.62 132	9.98 792	33
	28	9.36 713	53	9.37 924	56	0.62 076	9.98 789	32
	29	9.36 766	53	9.37 980	55	0.62 020	9.98 786	31
	30	9.36 819	52	9.38 035	56	0.61 965	9.98 783	30
	31	9.36 871	53	9.38 091	56	0.61 909	9.98 780	29
	32	9.36 924	52	9.38 147	55	0.61 853	9.98 777	28
	33	9.36 976	52	9.38 202	55	0.61 798	9.98 774	27
	34	9.37 028	53	9.38 257	56	0.61 743	9.98 771	26
	35	9.37 081	52	9.38 313	55	0.61 687	9.98 768	25
	36	9.37 133	52	9.38 368	55	0.61 632	9.98 765	24
	37	9.37 185	52	9.38 423	56	0.61 577	9.98 762	23
	38	9.37 237	52	9.38 479	55	0.61 521	9.98 759	22
	39	9.37 289	52	9.38 534	55	0.61 466	9.98 756	21
	40	9.37 341	52	9.38 589	55	0.61 411	9.98 753	20
	41	9.37 393	52	9.38 644	55	0.61 356	9.98 750	19
	42	9.37 445	52	9.38 699	55	0.61 301	9.98 746	18
	43	9.37 497	52	9.38 754	54	0.61 246	9.98 743	17
	44	9.37 549	51	9.38 808	55	0.61 192	9.98 740	16
	45	9.37 600	52	9.38 863	55	0.61 137	9.98 737	15
	46	9.37 652	51	9.38 918	54	0.61 082	9.98 734	14
	47	9.37 703	52	9.38 972	55	0.61 028	9.98 731	13
	48	9.37 755	51	9.39 027	55	0.60 973	9.98 728	12
	49	9.37 806	52	9.39 082	54	0.60 918	9.98 725	11
	50	9.37 858	51	9.39 136	54	0.60 864	9.98 722	10
	51	9.37 909	51	9.39 190	55	0.60 810	9.98 719	9
	52	9.37 960	51	9.39 245	54	0.60 755	9.98 715	8
	53	9.38 011	51	9.39 299	54	0.60 701	9.98 712	7
	54	9.38 062	51	9.39 353	54	0.60 647	9.98 709	6
	55	9.38 113	51	9.39 407	54	0.60 593	9.98 706	5
	56	9.38 164	51	9.39 461	54	0.60 539	9.98 703	4
	57	9.38 215	51	9.39 515	54	0.60 485	9.98 700	3
	58	9.38 266	51	9.39 569	54	0.60 431	9.98 697	2
	59	9.38 317	51	9.39 623	54	0.60 377	9.98 694	1
	60	9.38 368		9.39 677		0.60 323	9.98 690	0
346°—, 166°— / 256°—, 76°—		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	

PROP. PTS.

	58	57
1	5.8	5.7
2	11.6	11.4
3	17.4	17.1
4	23.2	22.8
5	29.0	28.5
6	34.8	34.2
7	40.6	39.9
8	46.4	45.6
9	52.2	51.3

	56	55
1	5.6	5.5
2	11.2	11.0
3	16.8	16.5
4	22.4	22.0
5	28.0	27.5
6	33.6	33.0
7	39.2	38.5
8	44.8	44.0
9	50.4	49.5

	54
1	5.4
2	10.8
3	16.2
4	21.6
5	27.0
6	32.4
7	37.8
8	43.2
9	48.6

	53	52
1	5.3	5.2
2	10.6	10.4
3	15.9	15.6
4	21.2	20.8
5	26.5	26.0
6	31.8	31.2
7	37.1	36.4
8	42.4	41.6
9	47.7	46.8

	51	4
1	5.1	0.4
2	10.2	0.8
3	15.3	1.2
4	20.4	1.6
5	25.5	2.0
6	30.6	2.4
7	35.7	2.8
8	40.8	3.2
9	45.9	3.6

	3	2
1	0.3	0.2
2	0.6	0.4
3	0.9	0.6
4	1.2	0.8
5	1.5	1.0
6	1.8	1.2
7	2.1	1.4
8	2.4	1.6
9	2.7	1.8

14°—, 194°— / 104°—, 284°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.38 368	50	9.39 677	54	0.60 323	9.98 690	3	60
	1	9.38 418	51	9.39 731	54	0.60 269	9.98 687	3	59
	2	9.38 469	50	9.39 785	53	0.60 215	9.98 684	3	58
	3	9.38 519	51	9.39 838	54	0.60 162	9.98 681	3	57
	4	9.38 570	50	9.39 892	53	0.60 108	9.98 678	3	56
	5	9.38 620	50	9.39 945	54	0.60 055	9.98 675	4	55
	6	9.38 670	51	9.39 999	53	0.60 001	9.98 671	3	54
	7	9.38 721	50	9.40 052	54	0.59 948	9.98 668	3	53
	8	9.38 771	50	9.40 106	53	0.59 894	9.98 665	3	52
	9	9.38 821	50	9.40 159	53	0.59 841	9.98 662	3	51
	10	9.38 871	50	9.40 212	54	0.59 788	9.98 659	3	50
	11	9.38 921	50	9.40 206	53	0.59 734	9.98 656	4	49
	12	9.38 971	50	9.40 319	53	0.59 681	9.98 652	3	48
	13	9.39 021	50	9.40 372	53	0.59 628	9.98 649	3	47
	14	9.39 071	50	9.40 425	53	0.59 575	9.98 646	3	46
	15	9.39 121	49	9.40 478	53	0.59 522	9.98 643	3	45
	16	9.39 170	50	9.40 531	53	0.59 469	9.98 640	4	44
	17	9.39 220	50	9.40 584	52	0.59 416	9.98 636	3	43
	18	9.39 270	49	9.40 636	53	0.59 364	9.98 633	3	42
	19	9.39 319	50	9.40 689	53	0.59 311	9.98 630	3	41
	20	9.39 369	49	9.40 742	53	0.59 258	9.98 627	4	40
	21	9.39 418	49	9.40 795	52	0.59 205	9.98 623	3	39
	22	9.39 467	50	9.40 847	53	0.59 153	9.98 620	3	38
	23	9.39 517	49	9.40 900	52	0.59 100	9.98 617	3	37
	24	9.39 566	49	9.40 952	53	0.59 048	9.98 614	4	36
	25	9.39 615	49	9.41 005	52	0.58 995	9.98 610	3	35
	26	9.39 664	49	9.41 057	52	0.58 943	9.98 607	3	34
	27	9.39 713	49	9.41 109	52	0.58 891	9.98 604	3	33
	28	9.39 762	49	9.41 161	53	0.58 839	9.98 601	4	32
	29	9.39 811	49	9.41 214	52	0.58 876	9.98 597	3	31
	30	9.39 860	49	9.41 266	52	0.58 734	9.98 594	3	30
	31	9.39 909	49	9.41 318	52	0.58 682	9.98 591	3	29
	32	9.39 958	48	9.41 370	52	0.58 630	9.98 588	4	28
	33	9.40 006	49	9.41 422	52	0.58 578	9.98 584	3	27
	34	9.40 055	48	9.41 474	52	0.58 526	9.98 581	3	26
	35	9.40 103	49	9.41 526	52	0.58 474	9.98 578	4	25
	36	9.40 152	48	9.41 578	51	0.58 422	9.98 574	3	24
	37	9.40 200	49	9.41 629	52	0.58 371	9.98 571	3	23
	38	9.40 249	48	9.41 681	52	0.58 319	9.98 568	3	22
	39	9.40 297	49	9.41 733	51	0.58 267	9.98 565	4	21
	40	9.40 346	48	9.41 784	52	0.58 216	9.98 561	3	20
	41	9.40 394	48	9.41 836	51	0.58 164	9.98 558	3	19
	42	9.40 442	48	9.41 887	52	0.58 113	9.98 555	4	18
	43	9.40 490	48	9.41 939	51	0.58 061	9.98 551	3	17
	44	9.40 538	48	9.41 990	51	0.58 010	9.98 548	3	16
	45	9.40 586	48	9.42 041	52	0.57 959	9.98 545	4	15
	46	9.40 634	48	9.42 093	51	0.57 907	9.98 541	3	14
	47	9.40 682	48	9.42 144	51	0.57 856	9.98 538	3	13
	48	9.40 730	48	9.42 195	51	0.57 805	9.98 535	4	12
	49	9.40 778	47	9.42 246	51	0.57 754	9.98 531	3	11
	50	9.40 825	48	9.42 297	51	0.57 703	9.98 528	3	10
	51	9.40 873	48	9.42 348	51	0.57 652	9.98 525	4	9
	52	9.40 921	47	9.42 399	51	0.57 601	9.98 521	3	8
	53	9.40 968	48	9.42 450	51	0.57 550	9.98 518	3	7
	54	9.41 016	47	9.42 501	51	0.57 499	9.98 515	4	6
	55	9.41 063	48	9.42 552	51	0.57 448	9.98 511	3	5
	56	9.41 111	47	9.42 603	50	0.57 397	9.98 508	3	4
	57	9.41 158	47	9.42 653	51	0.57 347	9.98 505	4	3
	58	9.41 205	47	9.42 704	51	0.57 296	9.98 501	3	2
	59	9.41 252	48	9.42 755	50	0.57 245	9.98 498	4	1
	60	9.41 300		9.42 805		0.57 195	9.98 494		0
345°—, 165°— / 255°—, 75°—		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′

PROP. PTS.

	54	53	52	51	50	49	48	47	4	3
1	5.4	5.3	5.2	5.1	5.0	4.9	4.8	4.7	0.4	0.3
2	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.4	0.8	0.6
3	16.2	15.9	15.6	15.3	15.0	14.7	14.4	14.1	1.2	0.9
4	21.6	21.2	20.8	20.4	20.0	19.6	19.2	18.8	1.6	1.2
5	27.0	26.5	26.0	25.5	25.0	24.5	24.0	23.5	2.0	1.5
6	32.4	31.8	31.2	30.6	30.0	29.4	28.8	28.2	2.4	1.8
7	37.8	37.1	36.4	35.7	35.0	34.3	33.6	32.9	2.8	2.1
8	43.2	42.4	41.6	40.8	40.0	39.2	38.4	37.6	3.2	2.4
9	48.6	47.7	46.8	45.9	45.0	44.1	43.2	42.3	3.6	2.7

15°__, 195°__ / 105°__, 285°__	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
	0	9.41 300	47	9.42 805	51	0.57 195	9.98 494	3	60
	1	9.41 347	47	9.42 856	50	0.57 144	9.98 491	3	59
	2	9.41 394	47	9.42 906	51	0.57 094	9.98 488	4	58
	3	9.41 441	47	9.42 957	50	0.57 043	9.98 484	3	57
	4	9.41 488	47	9.43 007	50	0.56 993	9.98 481	4	56
	5	9.41 535	47	9.43 057	51	0.56 943	9.98 477	3	55
	6	9.41 582	46	9.43 108	50	0.56 892	9.98 474	3	54
	7	9.41 628	47	9.43 158	50	0.56 842	9.98 471	4	53
	8	9.41 675	47	9.43 208	50	0.56 792	9.98 467	3	52
	9	9.41 722	46	9.43 258	50	0.56 742	9.98 464	4	51
	10	9.41 768	47	9.43 308	50	0.56 692	9.98 460	3	50
	11	9.41 815	46	9.43 358	50	0.56 642	9.98 457	4	49
	12	9.41 861	47	9.43 408	50	0.56 592	9.98 453	3	48
	13	9.41 908	46	9.43 458	50	0.56 542	9.98 450	3	47
	14	9.41 954	47	9.43 508	50	0.56 492	9.98 447	4	46
	15	9.42 001	46	9.43 558	49	0.56 442	9.98 443	3	45
	16	9.42 047	46	9.43 607	50	0.56 393	9.98 440	4	44
	17	9.42 093	47	9.43 657	50	0.56 343	9.98 436	3	43
	18	9.42 140	46	9.43 707	49	0.56 293	9.98 433	4	42
	19	9.42 186	46	9.43 756	50	0.56 244	9.98 429	3	41
	20	9.42 232	46	9.43 806	49	0.56 194	9.98 426	4	40
	21	9.42 278	46	9.43 855	50	0.56 145	9.98 422	3	39
	22	9.42 324	46	9.43 905	49	0.56 095	9.98 419	4	38
	23	9.42 370	46	9.43 954	50	0.56 046	9.98 415	3	37
	24	9.42 416	45	9.44 004	49	0.55 996	9.98 412	3	36
	25	9.42 461	46	9.44 053	49	0.55 947	9.98 409	4	35
	26	9.42 507	46	9.44 102	49	0.55 898	9.98 405	3	34
	27	9.42 553	46	9.44 151	50	0.55 849	9.98 402	4	33
	28	9.42 599	45	9.44 201	49	0.55 799	9.98 398	3	32
	29	9.42 644	46	9.44 250	49	0.55 750	9.98 395	4	31
	30	9.42 690	45	9.44 299	49	0.55 701	9.98 391	3	30
	31	9.42 735	46	9.44 348	49	0.55 652	9.98 388	4	29
	32	9.42 781	45	9.44 397	49	0.55 603	9.98 384	3	28
	33	9.42 826	46	9.44 446	49	0.55 554	9.98 381	4	27
	34	9.42 872	45	9.44 495	49	0.55 505	9.98 377	4	26
	35	9.42 917	45	9.44 544	48	0.55 456	9.98 373	3	25
	36	9.42 962	46	9.44 592	49	0.55 408	9.98 370	4	24
	37	9.43 008	45	9.44 641	49	0.55 359	9.98 366	3	23
	38	9.43 053	45	9.44 690	48	0.55 310	9.98 363	4	22
	39	9.43 098	45	9.44 738	49	0.55 262	9.98 359	3	21
	40	9.43 143	45	9.44 787	49	0.55 213	9.98 356	4	20
	41	9.43 188	45	9.44 836	48	0.55 164	9.98 352	3	19
	42	9.43 233	45	9.44 884	49	0.55 116	9.98 349	4	18
	43	9.43 278	45	9.44 933	48	0.55 067	9.98 345	3	17
	44	9.43 323	44	9.44 981	48	0.55 019	9.98 342	4	16
	45	9.43 367	45	9.45 029	49	0.54 971	9.98 338	4	15
	46	9.43 412	45	9.45 078	48	0.54 922	9.98 334	3	14
	47	9.43 457	45	9.45 126	48	0.54 874	9.98 331	4	13
	48	9.43 502	44	9.45 174	48	0.54 826	9.98 327	3	12
	49	9.43 546	45	9.45 222	49	0.54 778	9.98 324	4	11
	50	9.43 5591	44	9.45 271	48	0.54 729	9.98 320	3	10
	51	9.43 635	45	9.45 319	48	0.54 681	9.98 317	4	9
	52	9.43 680	44	9.45 367	48	0.54 633	9.98 313	4	8
	53	9.43 724	45	9.45 415	48	0.54 585	9.98 309	3	7
	54	9.43 769	44	9.45 463	48	0.54 537	9.98 306	4	6
	55	9.43 813	44	9.45 511	48	0.54 489	9.98 302	3	5
	56	9.43 857	44	9.45 559	47	0.54 441	9.98 299	4	4
	57	9.43 901	45	9.45 606	48	0.54 394	9.98 295	4	3
	58	9.43 946	44	9.45 654	48	0.54 346	9.98 291	3	2
	59	9.43 990	44	9.45 702	48	0.54 298	9.98 288	4	1
	60	9.44 034		9.45 750		0.54 250	9.98 284		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'

PROP. PTS.

	51	50	49	48	47	46	45	44	4	3
1	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	0.4	0.3
2	10.2	10.0	9.8	9.6	9.4	9.2	9.0	8.8	0.8	0.6
3	15.3	15.0	14.7	14.4	14.1	13.8	13.5	13.2	1.2	0.9
4	20.4	20.0	19.6	19.2	18.8	18.4	18.0	17.6	1.6	1.2
5	25.5	25.0	24.5	24.0	23.5	23.0	22.5	22.0	2.0	1.5
6	30.6	30.0	29.4	28.8	28.2	27.6	27.0	26.4	2.4	1.8
7	35.7	35.0	34.3	33.6	32.9	32.2	31.5	30.8	2.8	2.1
8	40.8	40.0	39.2	38.4	37.6	36.8	36.0	35.2	3.2	2.4
9	45.9	45.0	44.1	43.2	42.3	41.4	40.5	39.6	3.6	2.7

344°__, 164°__ / 254°__, 74°__

16°..., 196°...	'	L SIN	D	L TAN	CD	L COT	L COS	D	'
106°..., 286°...		L COS		L COT		L TAN	L SIN		
	0	9.44 034	44	9.45 750	47	0.54 250	9.98 284	3	60
	1	9.44 078	44	9.45 797	48	0.54 203	9.98 281	4	59
	2	9.44 122	44	9.45 845	47	0.54 155	9.98 277	4	58
	3	9.44 166	44	9.45 892	48	0.54 108	9.98 273	3	57
	4	9.44 210	43	9.45 940	47	0.54 060	9.98 270	4	56
	5	9.44 253	44	9.45 987	48	0.54 013	9.98 266	4	55
	6	9.44 297	44	9.46 035	47	0.53 965	9.98 262	3	54
	7	9.44 341	44	9.46 082	48	0.53 918	9.98 259	4	53
	8	9.44 385	43	9.46 130	47	0.53 870	9.98 255	4	52
	9	9.44 428	44	9.46 177	47	0.53 823	9.98 251	3	51
	10	9.44 472	44	9.46 224	47	0.53 776	9.98 248	4	50
	11	9.44 516	43	9.46 271	48	0.53 729	9.98 244	4	49
	12	9.44 559	43	9.46 319	47	0.53 681	9.98 240	3	48
	13	9.44 602	44	9.46 366	47	0.53 634	9.98 237	4	47
	14	9.44 646	43	9.46 413	47	0.53 587	9.98 233	4	46
	15	9.44 689	44	9.46 460	47	0.53 540	9.98 229	3	45
	16	9.44 733	43	9.46 507	47	0.53 493	9.98 226	4	44
	17	9.44 776	43	9.46 554	47	0.53 446	9.98 222	4	43
	18	9.44 819	43	9.46 601	47	0.53 399	9.98 218	3	42
	19	9.44 862	43	9.46 648	46	0.53 352	9.98 215	4	41
	20	9.44 905	43	9.46 694	47	0.53 306	9.98 211	4	40
	21	9.44 948	44	9.46 711	47	0.53 259	9.98 207	3	39
	22	9.44 992	43	9.46 788	47	0.53 212	9.98 204	4	38
	23	9.45 035	42	9.46 835	46	0.53 165	9.98 200	4	37
	24	9.45 077	43	9.46 861	47	0.53 119	9.98 196	4	36
	25	9.45 120	43	9.46 928	47	0.53 072	9.98 192	3	35
	26	9.45 163	43	9.46 975	46	0.53 025	9.98 189	4	34
	27	9.45 206	43	9.47 021	47	0.52 979	9.98 185	4	33
	28	9.45 249	43	9.47 068	46	0.52 932	9.98 181	4	32
	29	9.45 292	42	9.47 114	46	0.52 886	9.98 177	3	31
	30	9.45 334	43	9.47 160	47	0.52 840	9.98 174	4	30
	31	9.45 377	42	9.47 207	46	0.52 793	9.98 170	4	29
	32	9.45 419	43	9.47 253	46	0.52 747	9.98 166	4	28
	33	9.45 462	42	9.47 299	47	0.52 701	9.98 162	3	27
	34	9.45 504	43	9.47 346	46	0.52 654	9.98 159	4	26
	35	9.45 547	42	9.47 392	46	0.52 608	9.98 155	4	25
	36	9.45 589	43	9.47 438	46	0.52 562	9.98 151	4	24
	37	9.45 632	42	9.47 484	46	0.52 516	9.98 147	3	23
	38	9.45 674	42	9.47 530	46	0.52 470	9.98 144	4	22
	39	9.45 716	42	9.47 576	46	0.52 424	9.98 140	4	21
	40	9.45 758	43	9.47 622	46	0.52 378	9.98 136	4	20
	41	9.45 801	42	9.47 668	46	0.52 332	9.98 132	3	19
	42	9.45 843	42	9.47 714	46	0.52 286	9.98 129	4	18
	43	9.45 885	42	9.47 760	46	0.52 240	9.98 125	4	17
	44	9.45 927	42	9.47 806	46	0.52 194	9.98 121	4	16
	45	9.45 969	42	9.47 852	45	0.52 148	9.98 117	4	15
	46	9.46 011	42	9.47 897	46	0.52 103	9.98 113	3	14
	47	9.46 053	42	9.47 943	46	0.52 057	9.98 110	4	13
	48	9.46 095	41	9.47 989	46	0.52 011	9.98 106	4	12
	49	9.46 136	42	9.48 035	45	0.51 965	9.98 102	4	11
	50	9.46 178	42	9.48 080	46	0.51 920	9.98 098	4	10
	51	9.46 220	42	9.48 126	45	0.51 874	9.98 004	4	9
	52	9.46 262	41	9.48 171	46	0.51 829	9.98 090	3	8
	53	9.46 303	42	9.48 217	45	0.51 783	9.98 087	4	7
	54	9.46 345	41	9.48 262	45	0.51 738	9.98 083	4	6
	55	9.46 336	42	9.48 307	46	0.51 693	9.98 079	4	5
	56	9.46 428	41	9.48 353	45	0.51 647	9.98 075	4	4
	57	9.46 469	42	9.48 398	45	0.51 602	9.98 071	4	3
	58	9.46 511	41	9.48 443	46	0.51 557	9.98 067	4	2
	59	9.46 552	42	9.48 489	45	0.51 511	9.98 063	3	1
	60	9.46 594		9.48 534		0.51 466	9.98 060		0
		L SIN	D	L TAN	CD	L COT	L COS	D	'
		L COS		L COT		L TAN	L SIN		

PROP. PTS.

	48	47
1	4.8	4.7
2	9.6	9.4
3	14.4	14.1
4	19.2	18.8
5	24.0	23.5
6	28.8	28.2
7	33.6	32.9
8	38.4	37.6
9	43.2	42.3

	46	45
1	4.6	4.5
2	9.2	9.0
3	13.8	13.5
4	18.4	18.0
5	23.0	22.5
6	27.6	27.0
7	32.2	31.5
8	36.8	36.0
9	41.4	40.5

	44	43
1	4.4	4.3
2	8.8	8.6
3	13.2	12.9
4	17.6	17.2
5	22.0	21.5
6	26.4	25.8
7	30.8	30.1
8	35.2	34.4
9	39.6	38.7

	42	41
1	4.2	4.1
2	8.4	8.2
3	12.6	12.3
4	16.8	16.4
5	21.0	20.5
6	25.2	24.6
7	29.4	28.7
8	33.6	32.8
9	37.8	36.9

	4	3
1	0.4	0.3
2	0.8	0.6
3	1.2	0.9
4	1.6	1.2
5	2.0	1.5
6	2.4	1.8
7	2.8	2.1
8	3.2	2.4
9	3.6	2.7

343°..., 163°...

253°..., 73°...

17°—, 197°—	′	L SIN	D	L TAN	CD	L COT	L COS	D	
107°—, 287°—		L COS		L COT		L TAN	L SIN		
	0	9.46 594	41	9.48 534	45	0.51 466	9.98 060	4	60
	1	9.46 635	41	9.48 579	45	0.51 421	9.98 056	4	59
	2	9.46 676	41	9.48 624	45	0.51 376	9.98 052	4	58
	3	9.46 717	41	9.48 669	45	0.51 331	9.98 048	4	57
	4	9.46 758	42	9.48 714	45	0.51 286	9.98 044	4	56
	5	9.46 800	41	9.48 759	45	0.51 241	9.98 040	4	55
	6	9.46 841	41	9.48 804	45	0.51 196	9.98 036	4	54
	7	9.46 882	41	9.48 849	45	0.51 151	9.98 032	3	53
	8	9.46 923	41	9.48 894	45	0.51 106	9.98 029	4	52
	9	9.46 964	41	9.48 939	45	0.51 061	9.98 025	4	51
	10	9.47 005	40	9.48 984	45	0.51 016	9.98 021	4	50
	11	9.47 045	41	9.49 029	44	0.50 971	9.98 017	4	49
	12	9.47 086	41	9.49 073	45	0.50 927	9.98 013	4	48
	13	9.47 127	41	9.49 118	45	0.50 882	9.98 009	4	47
	14	9.47 168	41	9.49 163	44	0.50 837	9.98 005	4	46
	15	9.47 209	40	9.49 207	45	0.50 793	9.98 001	4	45
	16	9.47 249	41	9.49 252	44	0.50 748	9.97 997	4	44
	17	9.47 290	40	9.49 296	45	0.50 704	9.97 993	4	43
	18	9.47 330	41	9.49 341	44	0.50 659	9.97 989	3	42
	19	9.47 371	40	9.49 385	45	0.50 615	9.97 986	4	41
	20	9.47 411	41	9.49 430	44	0.50 570	9.97 982	4	40
	21	9.47 452	40	9.49 474	45	0.50 526	9.97 978	4	39
	22	9.47 492	41	9.49 519	44	0.50 481	9.97 974	4	38
	23	9.47 533	40	9.49 563	44	0.50 437	9.97 970	4	37
	24	9.47 573	40	9.49 607	45	0.50 393	9.97 966	4	36
	25	9.47 613	41	9.49 652	44	0.50 348	9.97 962	4	35
	26	9.47 654	40	9.49 696	44	0.50 304	9.97 958	4	34
	27	9.47 694	40	9.49 740	44	0.50 260	9.97 954	4	33
	28	9.47 734	40	9.49 784	44	0.50 216	9.97 950	4	32
	29	9.47 774	40	9.49 828	44	0.50 172	9.97 946	4	31
	30	9.47 814	40	9.49 872	44	0.50 128	9.97 942	4	30
	31	9.47 854	40	9.49 916	44	0.50 084	9.97 938	4	29
	32	9.47 894	40	9.49 960	44	0.50 040	9.97 934	4	28
	33	9.47 934	40	9.50 004	44	0.49 996	9.97 930	4	27
	34	9.47 974	40	9.50 048	44	0.49 952	9.97 926	4	26
	35	9.48 014	40	9.50 092	44	0.49 908	9.97 922	4	25
	36	9.48 054	40	9.50 136	44	0.49 864	9.97 918	4	24
	37	9.48 094	39	9.50 180	43	0.49 820	9.97 914	4	23
	38	9.48 133	40	9.50 223	44	0.49 777	9.97 910	4	22
	39	9.48 173	40	9.50 267	44	0.49 733	9.97 906	4	21
	40	9.48 213	39	9.50 311	44	0.49 689	9.97 902	4	20
	41	9.48 252	40	9.50 355	43	0.49 645	9.97 898	4	19
	42	9.48 292	40	9.50 398	44	0.49 602	9.97 894	4	18
	43	9.48 332	39	9.50 442	43	0.49 558	9.97 890	4	17
	44	9.48 371	40	9.50 485	44	0.49 515	9.97 886	4	16
	45	9.48 411	39	9.50 529	43	0.49 471	9.97 882	4	15
	46	9.48 450	40	9.50 572	44	0.49 428	9.97 878	4	14
	47	9.48 490	39	9.50 616	43	0.49 384	9.97 874	4	13
	48	9.48 529	39	9.50 659	44	0.49 341	9.97 870	4	12
	49	9.48 568	39	9.50 703	43	0.49 297	9.97 866	5	11
	50	9.48 607	40	9.50 746	43	0.49 254	9.97 861	4	10
	51	9.48 647	39	9.50 789	44	0.49 211	9.97 857	4	9
	52	9.48 686	39	9.50 833	43	0.49 167	9.97 853	4	8
	53	9.48 725	39	9.50 876	43	0.49 124	9.97 849	4	7
	54	9.48 764	39	9.50 919	43	0.49 081	9.97 845	4	6
	55	9.48 803	39	9.50 962	43	0.49 038	9.97 841	4	5
	56	9.48 842	39	9.51 005	43	0.48 995	9.97 837	4	4
	57	9.48 881	39	9.51 048	44	0.48 952	9.97 833	4	3
	58	9.48 920	39	9.51 092	43	0.48 908	9.97 829	4	2
	59	9.48 959	39	9.51 135	43	0.48 865	9.97 825	4	1
	60	9.48 998		9.51 178		0.48 822	9.97 821		0
		L SIN	D	L TAN	CD	L COT	L COS	D	′
		L COS		L COT		L TAN	L SIN		

342°—, 162°—
252°—, 72°—

PROP. PTS.

	45	44
1	4.5	4.4
2	9.0	8.8
3	13.5	13.2
4	18.0	17.6
5	22.5	22.0
6	27.0	26.4
7	31.5	30.8
8	36.0	35.2
9	40.5	39.6

	43	42
1	4.3	4.2
2	8.6	8.4
3	12.9	12.6
4	17.2	16.8
5	21.5	21.0
6	25.8	25.2
7	30.1	29.4
8	34.4	33.6
9	38.7	37.8

	41	40
1	4.1	4.0
2	8.2	8.0
3	12.3	12.0
4	16.4	16.0
5	20.5	20.0
6	24.6	24.0
7	28.7	28.0
8	32.8	32.0
9	36.9	36.0

	39	5
1	3.9	0.5
2	7.8	1.0
3	11.7	1.5
4	15.6	2.0
5	19.5	2.5
6	23.4	3.0
7	27.3	3.5
8	31.2	4.0
9	35.1	4.5

	4	3
1	0.4	0.3
2	0.8	0.6
3	1.2	0.9
4	1.6	1.2
5	2.0	1.5
6	2.4	1.8
7	2.8	2.1
8	3.2	2.4
9	3.6	2.7

18°—, 198°— / 108°—, 288°—	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.48 098	39	9.51 178	43	0.48 822	9.97 821	4	60
1	9.49 037	39	9.51 221	43	0.48 779	9.97 817	5	59
2	9.49 076	39	9.51 264	42	0.48 736	9.97 812	4	58
3	9.49 115	38	9.51 306	43	0.48 694	9.97 808	4	57
4	9.49 153	39	9.51 349	43	0.48 651	9.97 804	4	56
5	9.49 192	39	9.51 392	43	0.48 608	9.97 800	4	55
6	9.49 231	38	9.51 435	43	0.48 565	9.97 796	4	54
7	9.49 269	39	9.51 478	42	0.48 522	9.97 792	4	53
8	9.49 308	39	9.51 520	43	0.48 480	9.97 788	4	52
9	9.49 347	38	9.51 563	43	0.48 437	9.97 784	5	51
10	9.49 385	39	9.51 606	42	0.48 394	9.97 779	4	50
11	9.49 424	38	9.51 648	43	0.48 352	9.97 775	4	49
12	9.49 462	38	9.51 691	43	0.48 309	9.97 771	4	48
13	9.49 500	39	9.51 734	42	0.48 266	9.97 767	4	47
14	9.49 539	38	9.51 776	43	0.48 224	9.97 763	4	46
15	9.49 577	38	9.51 819	42	0.48 181	9.97 759	5	45
16	9.49 615	39	9.51 861	42	0.48 139	9.97 754	4	44
17	9.49 654	38	9.51 903	43	0.48 097	9.97 750	4	43
18	9.49 692	38	9.51 946	42	0.48 054	9.97 746	4	42
19	9.49 730	38	9.51 988	43	0.48 012	9.97 742	4	41
20	9.49 768	38	9.52 031	42	0.47 969	9.97 738	4	40
21	9.49 806	38	9.52 073	42	0.47 927	9.97 734	5	39
22	9.49 844	38	9.52 115	42	0.47 885	9.97 729	4	38
23	9.49 822	38	9.52 157	43	0.47 843	9.97 725	4	37
24	9.49 920	38	9.52 200	42	0.47 800	9.97 721	4	36
25	9.49 958	38	9.52 242	42	0.47 758	9.97 717	4	35
26	9.49 996	38	9.52 284	42	0.47 716	9.97 713	5	34
27	9.50 034	38	9.52 326	42	0.47 674	9.97 708	4	33
28	9.50 072	38	9.52 368	42	0.47 632	9.97 704	4	32
29	9.50 110	38	9.52 410	42	0.47 590	9.97 700	4	31
30	9.50 148	37	9.52 452	42	0.47 548	9.97 699	5	30
31	9.50 185	38	9.52 494	42	0.47 506	9.97 691	4	29
32	9.50 223	38	9.52 536	42	0.47 464	9.97 687	4	28
33	9.50 281	37	9.52 578	42	0.47 422	9.97 683	4	27
34	9.50 298	38	9.52 620	41	0.47 380	9.97 679	5	26
35	9.50 336	38	9.52 661	42	0.47 339	9.97 674	4	25
36	9.50 374	37	9.52 703	42	0.47 297	9.97 670	4	24
37	9.50 411	38	9.52 745	42	0.47 255	9.97 666	4	23
38	9.50 449	37	9.52 787	42	0.47 213	9.97 662	5	22
39	9.50 486	37	9.52 829	41	0.47 171	9.97 657	4	21
40	9.50 523	38	9.52 870	42	0.47 130	9.97 653	4	20
41	9.50 561	37	9.52 912	41	0.47 088	9.97 649	4	19
42	9.50 598	37	9.52 953	42	0.47 047	9.97 645	5	18
43	9.50 635	38	9.52 995	42	0.47 005	9.97 640	4	17
44	9.50 673	37	9.52 037	41	0.46 963	9.97 636	4	16
45	9.50 710	37	9.53 078	42	0.46 922	9.97 632	4	15
46	9.50 747	37	9.53 120	41	0.46 880	9.97 628	5	14
47	9.50 784	37	9.53 161	41	0.46 839	9.97 623	4	13
48	9.50 821	37	9.53 202	42	0.46 798	9.97 619	4	12
49	9.50 858	38	9.53 244	41	0.46 756	9.97 615	5	11
50	9.50 896	37	9.53 285	42	0.46 715	9.97 610	4	10
51	9.50 933	37	9.53 327	41	0.46 673	9.97 606	4	9
52	9.50 970	37	9.53 368	41	0.46 632	9.97 602	5	8
53	9.51 007	36	9.53 409	41	0.46 591	9.97 597	4	7
54	9.51 043	37	9.53 450	42	0.46 550	9.97 593	4	6
55	9.51 080	37	9.53 492	41	0.46 508	9.97 589	5	5
56	9.51 117	37	9.53 533	41	0.46 467	9.97 584	4	4
57	9.51 154	37	9.53 574	41	0.46 426	9.97 580	4	3
58	9.51 191	36	9.53 615	41	0.46 385	9.97 576	5	2
59	9.51 227	37	9.53 656	41	0.46 344	9.97 571	4	1
60	9.51 264		9.53 697		0.46 303	9.97 567		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	341°—, 161°— / 251°—, 71°—

PROP. PTS.

	43	42
1	4.3	4.2
2	8.6	8.4
3	12.9	12.6
4	17.2	16.8
5	21.5	21.0
6	25.8	25.2
7	30.1	29.4
8	34.4	33.6
9	38.7	37.8

	41
1	4.1
2	8.2
3	12.3
4	16.4
5	20.5
6	24.6
7	28.7
8	32.8
9	36.9

	39	38
1	3.9	3.8
2	7.8	7.6
3	11.7	11.4
4	15.6	15.2
5	19.5	19.0
6	23.4	22.8
7	27.3	26.6
8	31.2	30.4
9	35.1	34.2

	37	36
1	3.7	3.6
2	7.4	7.2
3	11.1	10.8
4	14.8	14.4
5	18.5	18.0
6	22.2	21.6
7	25.9	25.2
8	29.6	28.8
9	33.3	32.4

	5	4
1	0.5	0.4
2	1.0	0.8
3	1.5	1.2
4	2.0	1.6
5	2.5	2.0
6	3.0	2.4
7	3.5	2.8
8	4.0	3.2
9	4.5	3.6

19°—, 199°—	'	L SIN	D	L TAN	CD	L COT	L COS	D	
109°—, 289°—		L COS		L COT		L TAN	L SIN		
	0	9.51 264	37	9.53 697	41	0.46 303	9.97 567	4	60
	1	9.51 301	37	9.53 738	41	0.46 262	9.97 563	5	59
	2	9.51 338	36	9.53 779	41	0.46 221	9.97 558	4	58
	3	9.51 374	37	9.53 820	41	0.46 180	9.97 554	4	57
	4	9.51 411	36	9.53 861	41	0.46 139	9.97 550	5	56
	5	9.51 447	37	9.53 902	41	0.46 098	9.97 545	4	55
	6	9.51 484	36	9.53 943	41	0.46 057	9.97 541	5	54
	7	9.51 520	37	9.53 984	41	0.46 016	9.97 536	4	53
	8	9.51 557	36	9.54 025	40	0.45 975	9.97 532	4	52
	9	9.51 593	36	9.54 065	41	0.45 935	9.97 528	5	51
	10	9.51 629	37	9.54 106	41	0.45 894	9.97 523	4	50
	11	9.51 666	36	9.54 147	40	0.45 853	9.97 519	4	49
	12	9.51 702	36	9.54 187	41	0.45 813	9.97 515	5	48
	13	9.51 738	36	9.54 228	41	0.45 772	9.97 510	4	47
	14	9.51 774	37	9.54 269	40	0.45 731	9.97 506	5	46
	15	9.51 811	36	9.54 309	41	0.45 691	9.97 501	4	45
	16	9.51 847	36	9.54 350	40	0.45 650	9.97 497	5	44
	17	9.51 883	36	9.54 390	41	0.45 610	9.97 492	4	43
	18	9.51 919	36	9.54 431	40	0.45 569	9.97 488	4	42
	19	8.51 955	36	9.54 471	41	0.45 529	9.97 484	5	41
	20	9.51 991	36	9.54 512	40	0.45 488	9.97 479	4	40
	21	9.52 027	36	9.54 552	41	0.45 448	9.97 475	5	39
	22	9.52 063	36	9.54 593	40	0.45 407	9.97 470	4	38
	23	9.52 099	36	9.54 633	40	0.45 367	9.97 466	5	37
	24	9.52 135	36	9.54 673	41	0.45 327	9.97 461	4	36
	25	9.52 171	36	9.54 714	40	0.45 286	9.97 457	4	35
	26	9.52 207	35	9.54 754	40	0.45 246	9.97 453	5	34
	27	9.52 242	36	9.54 794	41	0.45 206	9.97 448	4	33
	28	9.52 278	36	9.54 835	40	0.45 165	9.97 444	5	32
	29	9.52 314	36	9.54 875	40	0.45 125	9.97 439	4	31
	30	9.52 350	35	9.54 915	40	0.45 085	9.97 435	5	30
	31	9.52 385	36	9.54 955	40	0.45 045	9.97 430	4	29
	32	9.52 421	35	9.54 995	40	0.45 005	9.97 426	5	28
	33	9.52 456	36	9.55 035	40	0.44 965	9.97 421	4	27
	34	9.52 492	35	9.55 075	40	0.44 925	9.97 417	5	26
	35	9.52 527	36	9.55 115	40	0.44 885	9.97 412	4	25
	36	9.52 563	35	9.55 155	40	0.44 845	9.97 408	5	24
	37	9.52 598	36	9.55 195	40	0.44 805	9.97 403	4	23
	38	9.52 634	35	9.55 235	40	0.44 765	9.97 399	5	22
	39	9.52 669	36	9.55 275	40	0.44 725	9.97 394	4	21
	40	9.52 705	35	9.55 315	40	0.44 685	9.97 390	5	20
	41	9.52 740	35	9.55 355	40	0.44 645	9.97 385	4	19
	42	9.52 775	36	9.55 395	49	0.44 605	9.97 381	5	18
	43	9.52 811	35	9.55 434	40	0.44 566	9.97 376	4	17
	44	9.52 846	35	9.55 474	40	0.44 526	9.97 372	5	16
	45	9.52 881	35	9.55 514	40	0.44 486	9.97 367	4	15
	46	9.52 916	35	9.55 554	39	0.44 446	9.97 363	5	14
	47	9.52 951	35	9.55 593	40	0.44 407	9.97 358	5	13
	48	9.52 086	35	9.55 633	40	0.44 367	9.97 353	4	12
	49	9.53 021	35	9.55 673	39	0.44 327	9.97 349	5	11
	50	9.53 056	36	9.55 712	40	0.44 288	9.97 344	4	10
	51	9.53 092	34	9.55 752	39	0.44 248	9.97 340	5	9
	52	9.53 126	35	9.55 791	40	0.44 209	9.97 335	4	8
	53	9.53 161	35	9.55 831	39	0.44 169	9.97 331	5	7
	54	9.53 196	35	9.55 870	40	0.44 130	9.97 326	4	6
	55	9.53 231	35	9.55 910	39	0.44 090	9.97 322	5	5
	56	9.53 266	35	9.55 949	40	0.44 051	9.97 317	5	4
	57	9.53 301	35	9.55 989	39	0.44 011	9.97 312	4	3
	58	9.53 336	34	9.56 028	39	0.43 972	9.97 308	5	2
	59	9.53 370	35	9.56 067	40	0.43 933	9.97 303	4	1
	60	9.53 405		9.56 107		0.43 893	9.97 299		0
		L SIN	D	L TAN	CD	L COT	L COS	D	'
		L COS		L COT		L TAN	L SIN		

PROP. PTS. (340°—, 160°— / 250°—, 70°—)

	41	40
1	4.1	4.0
2	8.2	8.0
3	12.3	12.0
4	16.4	16.0
5	20.5	20.0
6	24.6	24.0
7	28.7	28.0
8	32.8	32.0
9	36.9	36.0

	39
1	3.9
2	7.8
3	11.7
4	15.6
5	19.5
6	23.4
7	27.3
8	31.2
9	35.1

	37	36
1	3.7	3.6
2	7.4	7.2
3	11.1	10.8
4	14.8	14.4
5	18.5	18.0
6	22.2	21.6
7	25.9	25.2
8	29.6	28.8
9	33.3	32.4

	35	34
1	3.5	3.4
2	7.0	6.8
3	10.5	10.2
4	14.0	13.6
5	17.5	17.0
6	21.0	20.4
7	24.5	23.8
8	28.0	27.2
9	31.5	30.6

	5	4
1	0.5	0.4
2	1.0	0.8
3	1.5	1.2
4	2.0	1.6
5	2.5	2.0
6	3.0	2.4
7	3.5	2.8
8	4.0	3.2
9	4.5	3.6

20°..., 200°...	'	L SIN	D	L TAN	CD	L COT	L COS	D	'
110°..., 290°...		L COS		L COT		L TAN	L SIN		
	0	9.53 405	35	9.56 107	39	0.43 893	9.97 299	5	60
	1	9.53 440	35	9.56 146	39	0.43 854	9.97 294	5	59
	2	9.53 475	34	9.56 185	39	0.43 815	9.97 289	4	58
	3	9.53 509	35	9.56 224	40	0.43 776	9.97 285	5	57
	4	9.53 544	34	9.56 264	49	0.43 736	9.97 280	4	56
	5	9.53 578	35	9.56 303	39	0.43 697	9.97 276	5	55
	6	9.53 613	34	9.56 342	39	0.43 658	9.97 271	5	54
	7	9.53 647	35	9.56 381	39	0.43 619	9.97 266	4	53
	8	9.53 682	34	9.56 420	39	0.43 580	9.97 262	5	52
	9	9.53 716	35	9.56 459	39	0.43 541	9.97 257	5	51
	10	9.53 751	34	9.56 498	39	0.43 502	9.97 252	4	50
	11	9.53 785	34	9.56 537	39	0.43 463	9.97 248	5	49
	12	9.53 819	35	9.56 576	39	0.43 424	9.97 243	5	48
	13	9.53 854	34	9.56 615	39	0.43 385	9.97 238	4	47
	14	9.53 888	34	9.56 654	39	0.43 346	9.97 234	5	46
	15	9.53 922	35	9.56 693	39	0.43 307	9.97 229	5	45
	16	9.53 957	34	9.56 732	39	0.43 268	9.97 224	4	44
	17	9.53 991	34	9.56 771	39	0.43 229	9.97 220	5	43
	18	9.54 025	34	9.56 810	39	0.43 190	9.97 215	5	42
	19	9.54 059	34	9.56 849	38	0.43 151	9.97 210	4	41
	20	9.54 093	34	9.56 887	39	0.43 113	9.97 206	5	40
	21	9.54 127	34	9.56 926	39	0.43 074	9.97 201	5	39
	22	9.54 161	34	9.56 965	39	0.43 035	9.97 196	4	38
	23	9.54 195	34	9.57 004	38	0.42 996	9.97 192	5	37
	24	9.54 229	34	9.57 042	39	0.42 958	9.97 187	5	36
	25	9.54 263	34	9.57 081	39	0.42 919	9.97 182	4	35
	26	9.54 297	34	9.57 120	38	0.42 880	9.97 178	5	34
	27	9.54 331	34	9.57 158	39	0.42 842	9.97 173	5	33
	28	9.54 365	34	9.57 197	38	0.42 803	9.97 168	5	32
	29	9.54 399	34	9.57 235	39	0.42 765	9.97 163	4	31
	30	9.54 433	33	9.57 274	38	0.42 726	9.97 159	5	30
	31	9.54 466	34	9.57 312	39	0.42 688	9.97 154	5	29
	32	9.54 500	34	9.57 351	38	0.42 649	9.97 149	4	28
	33	9.54 534	33	9.57 389	39	0.42 611	9.97 145	5	27
	34	9.54 567	34	9.57 428	38	0.42 572	9.97 140	5	26
	35	9.54 601	34	9.57 466	38	0.42 534	9.97 135	5	25
	36	9.54 635	33	9.57 504	39	0.42 496	9.97 130	4	24
	37	9.54 668	34	9.57 543	38	0.42 457	9.97 126	5	23
	38	9.54 702	33	9.57 581	38	0.42 419	9.97 121	5	22
	39	9.54 735	34	9.57 619	39	0.42 381	9.97 116	5	21
	40	9.54 769	33	9.57 658	38	0.42 342	9.97 111	4	20
	41	9.54 802	34	9.57 696	38	0.42 304	9.97 107	5	19
	42	9.54 836	33	9.57 734	38	0.42 266	9.97 102	5	18
	43	9.54 869	34	9.57 772	38	0.42 228	9.97 097	5	17
	44	9.54 903	33	9.57 810	39	0.42 190	9.97 092	5	16
	45	9.54 936	33	9.57 849	38	0.42 151	9.97 087	4	15
	46	9.54 969	34	9.57 887	38	0.42 113	9.97 083	5	14
	47	9.55 003	33	9.57 925	38	0.42 075	9.97 078	5	13
	48	9.55 036	33	9.57 963	38	0.42 037	9.97 073	5	12
	49	9.55 069	33	9.58 001	38	0.41 999	9.97 068	5	11
	50	9.55 102	34	9.58 039	38	0.41 961	9.97 063	4	10
	51	9.55 136	33	9.58 077	38	0.41 923	9.97 059	5	9
	52	9.55 169	33	9.58 115	38	0.41 885	9.97 054	5	8
	53	9.55 202	33	9.58 153	38	0.41 847	9.97 049	5	7
	54	9.55 235	33	9.58 191	38	0.41 809	9.97 044	5	6
	55	9.55 268	33	9.58 229	38	0.41 771	9.97 039	4	5
	56	9.55 301	33	9.58 267	37	0.41 733	9.97 035	5	4
	57	9.55 334	33	9.58 304	38	0.41 696	9.97 030	5	3
	58	9.55 367	33	9.58 342	38	0.41 658	9.97 025	5	2
	59	9.55 400	33	9.58 380	38	0.41 620	9.97 020	5	1
	60	9.55 433		9.58 418		0.41 582	9.97 015		0
		L SIN	D	L TAN	CD	L COT	L COS	D	'
		L COS		L COT		L TAN	L SIN		

339°..., 159°...
249°..., 69°...

PROP. PTS.

	40	39
1	4.0	3.9
2	8.0	7.8
3	12.0	11.7
4	16.0	15.6
5	20.0	19.5
6	24.0	23.4
7	28.0	27.3
8	32.0	31.2
9	36.0	35.1

	38	37
1	3.8	3.7
2	7.6	7.4
3	11.4	11.1
4	15.2	14.8
5	19.0	18.5
6	22.8	22.2
7	26.6	25.9
8	30.4	29.6
9	34.2	33.3

	35
1	3.5
2	7.0
3	10.5
4	14.0
5	17.5
6	21.0
7	24.5
8	28.0
9	31.5

	34	33
1	3.4	3.3
2	6.8	6.6
3	10.2	9.9
4	13.6	13.2
5	17.0	16.5
6	20.4	19.8
7	23.8	23.1
8	27.2	26.4
9	30.6	29.7

	5	4
1	0.5	0.4
2	1.0	0.8
3	1.5	1.2
4	2.0	1.6
5	2.5	2.0
6	3.0	2.4
7	3.5	2.8
8	4.0	3.2
9	4.5	3.6

21°__, 201°__	′	L SIN	D	L TAN	CD	L COT	L COS	D	
111°__, 291°__		L COS		L COT		L TAN	L SIN		
	0	9.55 433	33	9.58 418	37	0.41 582	9.97 015	5	60
	1	9.55 466	33	9.58 455	38	0.41 545	9.97 010	5	59
	2	9.55 499	33	9.58 493	38	0.41 507	9.97 005	4	58
	3	9.55 532	32	9.58 531	38	0.41 469	9.97 001	5	57
	4	9.55 564	33	9.58 569	37	0.41 431	9.96 996	5	56
	5	9.55 597	33	9.58 606	38	0.41 394	9.96 991	5	55
	6	9.55 630	33	9.58 644	37	0.41 356	9.96 986	5	54
	7	9.55 663	32	9.58 681	38	0.41 319	9.96 981	5	53
	8	9.55 695	33	9.58 719	38	0.41 281	9.96 976	5	52
	9	9.55 728	33	9.58 757	37	0.41 243	9.96 971	5	51
	10	9.55 761	32	9.58 794	38	0.41 206	9.96 966	4	50
	11	9.55 793	33	9.58 832	37	0.41 168	9.96 962	5	49
	12	9.55 826	32	9.58 869	38	0.41 131	9.96 957	5	48
	13	9.55 858	33	9.58 907	37	0.41 093	9.96 952	5	47
	14	9.55 891	32	9.58 944	37	0.41 056	9.96 947	5	46
	15	9.55 923	33	9.58 981	38	0.41 019	9.96 942	5	45
	16	9.55 956	32	9.59 019	37	0.40 981	9.96 937	5	44
	17	9.55 988	33	9.59 056	38	0.40 944	9.96 932	5	43
	18	9.56 021	32	9.59 094	37	0.40 906	9.96 927	5	42
	19	9.56 053	32	9.59 131	37	0.40 869	9.96 922	5	41
	20	9.56 085	33	9.59 168	37	0.40 832	9.96 917	5	40
	21	9.56 118	32	9.59 205	38	0.40 795	9.96 912	5	39
	22	9.56 150	32	9.59 243	37	0.40 757	9.96 907	4	38
	23	9.56 182	33	9.59 280	37	0.40 720	9.96 903	5	37
	24	9.56 215	32	9.59 317	37	0.40 683	9.96 898	5	36
	25	9.56 247	32	9.59 354	37	0.40 646	9.96 893	5	35
	26	9.56 279	32	9.59 391	38	0.40 609	9.96 888	5	34
	27	9.56 311	32	9.59 429	37	0.40 571	9.96 883	5	33
	28	9.56 343	32	9.59 466	37	0.40 534	9.96 878	5	32
	29	9.56 375	33	9.59 503	37	0.40 497	9.96 873	5	31
	30	9.56 408	32	9.59 540	37	0.40 460	9.96 868	5	30
	31	9.56 440	32	9.59 577	37	0.40 423	9.96 863	5	29
	32	9.56 472	32	9.59 614	37	0.40 386	9.96 858	5	28
	33	9.56 504	32	9.59 651	37	0.40 349	9.96 853	5	27
	34	9.56 536	32	9.59 688	37	0.40 312	9.96 848	5	26
	35	9.56 568	31	9.59 725	37	0.40 275	9.96 843	5	25
	36	9.56 599	32	9.59 762	37	0.40 238	9.96 838	5	24
	37	9.56 631	32	9.59 799	36	0.40 201	9.96 833	5	23
	38	9.56 663	32	9.59 835	37	0.40 165	9.96 828	5	22
	39	9.56 695	32	9.59 872	37	0.40 128	9.96 823	5	21
	40	9.56 727	32	9.59 909	37	0.40 091	9.96 818	5	20
	41	9.56 759	31	9.59 946	37	0.40 054	9.96 813	5	19
	42	9.56 790	32	9.59 983	36	0.40 017	9.96 808	5	18
	43	9.56 822	32	9.60 019	37	0.39 981	9.96 803	5	17
	44	9.56 854	32	9.60 056	37	0.39 944	9.96 798	5	16
	45	9.56 886	31	9.60 093	37	0.39 907	9.96 793	5	15
	46	9.56 917	32	9.60 130	36	0.39 870	9.96 788	5	14
	47	9.56 919	31	9.60 166	37	0.39 834	9.96 783	5	13
	48	9.56 980	32	9.60 203	37	0.39 797	9.96 778	5	12
	49	9.56 012	32	9.60 240	36	0.39 760	9.96 772	5	11
	50	9.57 044	31	9.60 276	37	0.39 724	9.96 767	5	10
	51	9.57 075	32	9.60 313	36	0.39 687	9.96 762	5	9
	52	9.57 107	31	9.60 349	37	0.39 651	9.96 757	5	8
	53	9.57 133	31	9.60 386	36	0.39 614	9.96 752	5	7
	54	9.57 169	32	9.60 422	37	0.39 578	9.96 747	5	6
	55	9.57 201	31	9.60 459	36	0.39 541	9.96 742	5	5
	56	9.57 232	32	9.60 495	37	0.39 505	9.96 737	5	4
	57	9.57 264	31	9.60 532	36	0.39 468	9.96 732	5	3
	58	9.57 295	31	9.60 568	37	0.39 432	9.96 727	5	2
	59	9.57 326	32	9.60 605	36	0.39 395	9.96 722	5	1
	60	9.57 358		9.60 641		0.39 359	9.96 717		0
		L SIN	D	L TAN	CD	L COT	L COS	D	′
		L COS		L COT		L TAN	L SIN		

338°__, 158°__

248°__, 68°__

PROP. PTS.

	38	37
1	3.8	3.7
2	7.6	7.4
3	11.4	11.1
4	15.2	14.8
5	19.0	18.5
6	22.8	22.2
7	26.6	25.9
8	30.4	29.6
9	34.2	33.3

	36	33
1	3.6	3.3
2	7.2	6.6
3	10.8	9.9
4	14.4	13.2
5	18.0	16.5
6	21.6	19.8
7	25.2	23.1
8	28.8	26.4
9	32.4	29.7

	32
1	3.2
2	6.4
3	9.6
4	12.8
5	16.0
6	19.2
7	22.4
8	25.6
9	28.8

	31	6
1	3.1	0.6
2	6.2	1.2
3	9.3	1.8
4	12.4	2.4
5	15.5	3.0
6	18.6	3.6
7	21.7	4.2
8	24.8	4.8
9	27.9	5.4

	5	4
1	0.5	0.4
2	1.0	0.8
3	1.5	1.2
4	2.0	1.6
5	2.5	2.0
6	3.0	2.4
7	3.5	2.8
8	4.0	3.2
9	4.5	3.6

22°..., 202°... / 112°..., 292°...	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.57 358	31	9.60 641	36	0.39 359	9.96 717	6	60
	1	9.57 389	31	9.60 677	37	0.39 323	9.96 711	5	59
	2	9.57 420	31	9.60 714	36	0.39 286	9.96 706	5	58
	3	9.57 451	31	9.60 750	36	0.39 250	9.96 701	5	57
	4	9.57 482	32	9.60 786	37	0.39 214	9.96 696	5	56
	5	9.57 514	31	9.60 823	36	0.39 177	9.96 691	5	55
	6	9.57 545	31	9.60 859	36	0.39 141	9.96 686	5	54
	7	9.57 576	31	9.60 895	36	0.39 105	9.96 681	5	53
	8	9.57 607	31	9.60 931	36	0.39 069	9.96 676	6	52
	9	9.57 638	31	9.60 967	37	0.39 033	9.96 670	5	51
	10	9.57 669	31	9.61 004	36	0.38 996	9.96 665	5	50
	11	9.57 700	31	9.61 040	36	0.38 960	9.96 660	5	49
	12	9.57 731	31	9.61 076	36	0.38 924	9.96 655	5	48
	13	9.57 762	31	9.61 112	36	0.38 888	9.96 650	5	47
	14	9.57 793	31	9.61 148	36	0.38 852	9.96 645	5	46
	15	9.57 824	31	9.61 184	36	0.38 816	9.96 640	6	45
	16	9.57 855	30	9.61 220	36	0.38 780	9.96 634	5	44
	17	9.57 885	31	9.61 256	36	0.38 744	9.96 629	5	43
	18	9.57 916	31	9.61 292	36	0.38 708	9.96 624	5	42
	19	9.57 947	31	9.61 328	36	0.38 672	9.96 619	5	41
	20	9.57 978	30	9.61 364	36	0.38 636	9.96 614	6	40
	21	9.58 008	31	9.61 400	36	0.38 600	9.96 608	5	39
	22	9.58 039	31	9.61 436	36	0.38 564	9.96 603	5	38
	23	9.58 070	31	9.61 472	36	0.38 528	9.96 598	5	37
	24	9.58 101	30	9.61 508	36	0.38 492	9.96 593	5	36
	25	9.58 131	31	9.61 544	35	0.38 456	9.96 588	6	35
	26	9.58 162	30	9.61 579	36	0.38 421	9.96 582	5	34
	27	9.58 192	31	9.61 615	36	0.38 385	9.96 577	5	33
	28	9.58 223	30	9.61 651	36	0.38 349	9.96 572	5	32
	29	9.58 253	31	9.61 687	35	0.38 313	9.96 567	5	31
	30	9.58 284	30	9.61 722	36	0.38 278	9.96 562	6	30
	31	9.58 314	31	9.61 758	36	0.38 242	9.96 556	5	29
	32	9.58 345	30	9.61 794	36	0.38 206	9.96 551	5	28
	33	9.58 375	31	9.61 830	35	0.38 170	9.96 546	5	27
	34	9.58 406	30	9.61 865	36	0.38 135	9.96 541	6	26
	35	9.58 346	31	9.61 901	35	0.38 099	9.96 535	5	25
	36	9.58 467	30	9.61 936	36	0.38 064	9.96 530	5	24
	37	9.58 497	30	9.61 972	36	0.38 028	9.96 525	5	23
	38	9.58 527	30	9.62 008	35	0.37 992	9.96 520	6	22
	39	9.58 557	31	9.62 043	36	0.37 957	9.96 514	5	21
	40	9.58 588	30	9.62 079	35	0.37 921	9.96 509	5	20
	41	9.58 618	30	9.62 114	36	0.37 886	9.96 504	6	19
	42	9.58 648	30	9.62 150	35	0.37 850	9.96 498	5	18
	43	9.58 678	31	9.62 185	36	0.37 815	9.96 493	5	17
	44	9.58 709	30	9.62 221	35	0.37 779	9.96 488	5	16
	45	9.58 739	30	9.62 256	36	0.37 744	9.96 483	6	15
	46	9.58 769	30	9.62 292	35	0.37 708	9.96 477	5	14
	47	9.58 799	30	9.62 327	35	0.37 673	9.96 472	5	13
	48	9.58 829	30	9.62 362	36	0.37 638	9.96 467	6	12
	49	9.58 859	30	9.62 398	35	0.37 602	9.96 461	5	11
	50	9.58 889	30	9.62 433	35	0.37 567	9.96 456	5	10
	51	9.58 919	30	9.62 468	36	0.37 532	9.96 451	6	9
	52	9.58 949	30	9.62 504	35	0.37 496	9.96 445	5	8
	53	9.58 979	30	9.62 539	35	0.37 461	9.96 440	5	7
	54	9.59 009	30	9.62 574	35	0.37 426	9.96 435	6	6
	55	9.59 039	30	9.62 609	36	0.37 391	9.96 429	5	5
	56	9.59 069	29	9.62 645	35	0.37 355	9.96 424	5	4
	57	9.59 098	30	9.62 680	35	0.37 320	9.96 419	6	3
	58	9.59 128	30	9.62 715	35	0.37 285	9.96 413	5	2
	59	9.59 158	30	9.62 750	35	0.37 250	9.96 408	5	1
	60	9.59 188		9.62 785		0.37 215	9.96 403		0
337°..., 157°... / 247°..., 67°...	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'

PROP. PTS.

	37	36
1	3.7	3.6
2	7.4	7.2
3	11.1	10.8
4	14.8	14.4
5	18.5	18.0
6	22.2	21.6
7	25.9	25.2
8	29.6	28.8
9	33.3	32.4

	35
1	3.5
2	7.0
3	10.5
4	14.0
5	17.5
6	21.0
7	24.5
8	28.0
9	31.5

	32	31
1	3.2	3.1
2	6.4	6.2
3	9.6	9.3
4	12.8	12.4
5	16.0	15.5
6	19.2	18.6
7	22.4	21.7
8	25.6	24.8
9	28.8	27.9

	30	29
1	3.0	2.9
2	6.0	5.8
3	9.0	8.7
4	12.0	11.6
5	15.0	14.5
6	18.0	17.4
7	21.0	20.3
8	24.0	23.2
9	27.0	26.1

	6	5
1	0.6	0.5
2	1.2	1.0
3	11.8	1.5
4	2.4	2.0
5	3.0	2.5
6	3.6	3.0
7	4.2	3.5
8	4.8	4.0
9	5.4	4.5

23°—, 203°— / 113°—, 293°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.59 188	30	9.62 785	35	0.37 215	9.96 403	6	60
	1	9.59 218	29	9.62 820	35	0.37 180	9.96 397	5	59
	2	9.59 247	30	9.62 855	35	0.37 145	9.96 392	5	58
	3	9.59 277	30	9.62 890	36	0.37 110	9.96 387	6	57
	4	9.59 307	29	9.62 926	35	0.37 074	9.96 381	5	56
	5	9.59 336	30	9.62 961	35	0.37 039	9.96 376	6	55
	6	9.59 366	30	9.62 996	35	0.37 004	9.96 370	5	54
	7	9.59 396	29	9.63 031	35	0.36 969	9.96 365	5	53
	8	9.59 125	30	9.63 066	35	0.36 934	9.96 360	6	52
	9	9.59 155	29	9.63 101	34	0.36 899	9.96 354	5	51
	10	9.59 484	30	9.63 135	35	0.36 865	9.96 349	6	50
	11	9.59 514	29	9.63 170	35	0.36 830	9.96 343	5	49
	12	9.59 543	30	9.63 205	35	0.36 795	9.96 338	5	48
	13	9.59 573	29	9.63 240	35	0.36 760	9.96 333	6	47
	14	9.59 602	30	9.63 275	35	0.36 725	9.96 327	5	46
	15	9.59 632	29	9.63 310	35	0.36 690	9.96 322	6	45
	16	9.59 661	29	9.63 345	34	0.36 655	9.96 316	5	44
	17	9.59 690	30	9.63 379	35	0.36 621	9.96 311	6	43
	18	9.59 720	29	9.63 414	35	0.36 586	9.96 305	5	42
	19	9.59 749	29	9.63 449	35	0.36 551	9.96 300	6	41
	20	9.59 778	30	9.63 484	35	0.36 516	9.96 294	5	40
	21	9.59 808	29	9.63 519	34	0.36 481	9.96 289	5	39
	22	9.59 837	29	9.63 553	35	0.36 447	9.96 284	6	38
	23	9.59 866	29	9.63 588	35	0.36 412	9.96 278	5	37
	24	9.59 895	29	9.63 623	34	0.36 377	9.96 273	6	36
	25	9.59 924	30	9.63 657	35	0.36 343	9.96 267	5	35
	26	9.59 954	29	9.63 692	34	0.36 308	9.96 262	6	34
	27	9.59 983	29	9.63 726	35	0.36 274	9.96 256	5	33
	28	9.60 012	29	9.63 761	35	0.36 239	9.96 251	6	32
	29	9.60 041	29	9.63 796	34	0.36 204	9.96 245	5	31
	30	9.60 070	29	9.63 830	35	0.36 170	9.96 240	6	30
	31	9.60 099	29	9.63 865	34	0.36 135	9.96 234	5	29
	32	9.60 128	29	9.63 899	35	0.36 101	9.96 229	6	28
	33	9.60 157	29	9.63 934	34	0.36 066	9.96 223	5	27
	34	9.60 186	29	9.63 968	35	0.36 032	9.96 218	6	26
	35	9.60 215	29	9.64 003	34	0.35 997	9.96 212	5	25
	36	9.60 244	29	9.64 037	35	0.35 963	9.96 207	6	24
	37	9.60 273	29	9.64 072	34	0.35 928	9.96 201	5	23
	38	9.60 302	29	9.64 106	34	0.35 894	9.96 196	6	22
	39	9.60 331	28	9.64 140	35	0.35 860	9.96 190	5	21
	40	9.60 359	29	9.64 175	34	0.35 825	9.96 185	6	20
	41	9.60 388	29	9.64 209	34	0.35 791	9.96 179	5	19
	42	9.60 417	29	9.64 243	35	0.35 757	9.96 174	6	18
	43	9.60 446	28	9.64 278	34	0.35 722	9.96 168	6	17
	44	9.60 474	29	9.64 312	34	0.35 688	9.96 162	5	16
	45	9.60 503	29	9.64 346	35	0.35 654	9.96 157	6	15
	46	9.60 532	29	9.64 381	34	0.35 619	9.96 151	5	14
	47	9.60 561	28	9.64 415	34	0.35 585	9.96 146	6	13
	48	9.60 589	29	9.64 449	34	0.35 551	9.96 140	5	12
	49	9.60 618	28	9.64 483	34	0.35 517	9.96 135	6	11
	50	9.60 646	29	9.64 517	35	0.35 483	9.96 129	6	10
	51	9.60 675	29	9.64 552	34	0.35 448	9.96 123	5	9
	52	9.60 704	28	9.64 586	34	0.35 414	9.96 118	6	8
	53	9.60 732	29	9.64 620	34	0.35 380	9.96 112	5	7
	54	9.60 761	28	9.64 654	34	0.35 346	9.96 107	6	6
	55	9.60 789	29	9.64 688	34	0.35 312	9.96 101	6	5
	56	9.60 818	28	9.64 722	34	0.35 278	9.96 095	5	4
	57	9.60 846	29	9.64 756	34	0.35 244	9.96 090	6	3
	58	9.60 875	28	9.64 790	34	0.35 210	9.96 084	5	2
	59	9.60 903	28	9.64 824	34	0.35 176	9.96 079	6	1
	60	9.60 931		9.64 858		0.35 142	9.96 073		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
									336°—, 156°— / 246°—, 66°—

PROP. PTS.

	36	35
1	3.6	3.5
2	7.2	7.0
3	10.8	10.5
4	14.4	14.0
5	18.0	17.5
6	21.6	21.0
7	25.2	24.5
8	28.8	28.0
9	32.4	31.5

	34
1	3.4
2	6.8
3	10.2
4	13.6
5	17.0
6	20.4
7	23.8
8	27.2
9	30.6

	30	29
1	3.0	2.9
2	6.0	5.8
3	9.0	8.7
4	12.0	11.6
5	15.0	14.5
6	18.0	17.4
7	21.0	20.3
8	24.0	23.2
9	27.0	26.1

	28
1	2.8
2	5.6
3	8.4
4	11.2
5	14.0
6	16.8
7	19.6
8	22.4
9	25.2

	6	5
1	0.6	0.5
2	1.2	1.0
3	1.8	1.5
4	2.4	2.0
5	3.0	2.5
6	3.6	3.0
7	4.2	3.5
8	4.8	4.0
9	5.4	4.5

24°..., 204°... / 114°..., 294°... '	L SIN	D	L TAN	CD	L COT	L COS	D	
	L COS		L COT		L TAN	L SIN		
0	9.60 931	29	9.64 858	34	0.35 142	9.96 073	6	60
1	9.60 960	28	9.64 892	34	0.35 108	9.96 067	5	59
2	9.60 988	28	9.64 926	34	0.35 074	9.96 062	6	58
3	9.61 016	29	9.64 960	34	0.35 040	9.96 056	6	57
4	9.61 045	28	9.64 994	34	0.35 006	9.96 050	5	56
5	9.61 073	28	9.65 028	34	0.34 972	9.96 045	6	55
6	9.61 101	28	9.65 062	34	0.34 938	9.96 039	5	54
7	9.61 129	29	9.65 096	34	0.34 904	9.96 034	6	53
8	9.61 158	28	9.65 130	34	0.34 870	9.96 028	6	52
9	9.61 186	28	9.65 164	33	0.34 836	9.96 022	5	51
10	9.61 214	28	9.65 197	34	0.34 803	9.96 017	6	50
11	9.61 242	28	9.65 231	34	0.34 769	9.96 011	6	49
12	9.61 270	28	9.65 265	34	0.34 735	9.96 005	5	48
13	9.61 298	28	9.65 299	34	0.34 701	9.96 000	6	47
14	9.61 326	28	9.65 333	33	0.34 667	9.95 994	6	46
15	9.61 354	28	9.65 366	34	0.34 634	9.95 988	6	45
16	9.61 382	29	9.65 400	34	0.34 600	9.95 982	5	44
17	9.61 411	27	9.65 434	33	0.34 566	9.95 977	6	43
18	9.61 438	28	9.65 467	34	0.34 533	9.95 971	6	42
19	9.61 466	28	9.65 501	34	0.34 499	9.95 965	5	41
20	9.61 494	28	9.65 535	33	0.34 465	9.95 960	6	40
21	9.61 522	28	9.65 568	34	0.34 432	9.95 954	6	39
22	9.61 550	28	9.65 602	34	0.34 398	9.95 948	6	38
23	9.61 578	28	9.65 636	33	0.34 364	9.95 942	5	37
24	9.61 606	28	9.65 669	34	0.34 331	9.95 937	6	36
25	9.61 634	28	9.65 703	33	0.34 297	9.95 931	6	35
26	9.61 662	27	9.65 736	34	0.34 264	9.95 925	5	34
27	9.61 689	28	9.65 770	33	0.34 230	9.95 920	6	33
28	9.61 717	28	9.65 803	34	0.34 197	9.95 914	6	32
29	9.61 745	28	9.65 837	33	0.34 163	9.95 908	6	31
30	9.61 773	27	9.65 870	34	0.34 130	9.95 902	5	30
31	9.61 800	28	9.65 904	33	0.34 096	9.95 897	6	29
32	9.61 828	28	9.65 937	34	0.34 063	9.95 891	6	28
33	9.61 856	27	9.65 971	33	0.34 029	9.95 885	6	27
34	9.61 883	28	9.66 004	34	0.33 996	9.95 879	6	26
35	9.61 911	28	9.66 038	33	0.33 962	9.95 873	5	25
36	9.61 939	27	9.66 071	33	0.33 929	9.95 868	6	24
37	9.61 966	28	9.66 104	34	0.33 896	9.95 862	6	23
38	9.61 994	27	9.66 138	33	0.33 862	9.95 856	6	22
39	9.62 021	28	9.66 171	33	0.33 829	9.95 850	6	21
40	9.62 049	27	9.66 204	34	0.33 796	9.95 844	5	20
41	9.62 076	28	9.66 238	33	0.33 762	9.95 839	6	19
42	9.62 104	27	9.66 271	33	0.33 729	9.95 833	6	18
43	9.62 131	28	9.66 304	33	0.33 696	9.95 827	6	17
44	9.62 159	27	9.66 337	34	0.33 663	9.95 821	6	16
45	9.62 186	28	9.66 371	33	0.33 629	9.95 815	5	15
46	9.62 214	27	9.66 404	33	0.33 596	9.95 810	6	14
47	9.62 241	27	9.66 437	33	0.33 563	9.95 804	6	13
48	9.62 268	28	9.66 470	33	0.33 530	9.95 798	6	12
49	9.62 296	27	9.66 503	34	0.33 497	9.95 792	6	11
50	9.62 323	27	9.66 527	33	0.33 463	9.95 786	6	10
51	9.62 350	27	9.66 570	33	0.33 430	9.95 780	5	9
52	9.62 377	28	9.66 603	33	0.33 397	9.95 775	6	8
53	9.62 405	27	9.66 636	33	0.33 364	9.95 769	6	7
54	9.62 432	27	9.66 669	33	0.33 331	9.95 763	6	6
55	9.62 459	27	9.66 702	33	0.33 298	9.95 757	6	5
56	9.62 486	27	9.66 735	33	0.33 265	9.95 751	6	4
57	9.62 513	28	9.66 768	33	0.33 232	9.95 745	6	3
58	9.62 541	27	9.66 801	33	0.33 199	9.95 739	6	2
59	9.62 568	27	9.66 834	33	0.33 166	9.95 733	5	1
60	9.62 595		9.66 867		0.33 133	9.95 728		0
	L SIN	D	L TAN	CD	L COT	L COS	D	'
	L COS		L COT		L TAN	L SIN		335°..., 155°... / 245..., 65°...

PROP. PTS.

	34	33
1	3.4	3.3
2	6.8	6.6
3	10.2	9.9
4	13.6	13.2
5	17.0	16.5
6	20.4	19.8
7	23.8	23.1
8	27.2	26.4
9	30.6	29.7

	29
1	2.9
2	5.8
3	8.7
4	11.6
5	14.5
6	17.4
7	20.3
8	23.2
9	26.1

	28
1	2.8
2	5.6
3	8.4
4	11.2
5	14.0
6	16.8
7	19.6
8	22.4
9	25.2

	27
1	2.7
2	5.4
3	8.1
4	10.8
5	13.5
6	16.2
7	18.9
8	21.6
9	24.3

	6	5
1	0.6	0.5
2	1.2	1.0
3	1.8	1.5
4	2.4	2.0
5	3.0	2.5
6	3.6	3.0
7	4.2	3.5
8	4.8	4.0
9	5.4	4.5

25°—, 205°— / 115°—, 295°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
	0	9.62 595	27	9.66 867	33	0.33 133	9.95 728	6	60
	1	9.62 622	27	9.66 900	33	0.33 100	9.95 722	6	59
	2	9.62 649	27	9.66 933	33	0.33 067	9.95 716	6	58
	3	9.62 676	27	9.66 966	33	0.33 034	9.95 710	6	57
	4	9.62 703	27	9.66 999	33	0.33 001	9.95 704	6	56
	5	9.62 730	27	9.67 032	33	0.32 968	9.95 698	6	55
	6	9.62 757	27	9.67 065	33	0.32 935	9.95 692	6	54
	7	9.62 784	27	9.67 098	33	0.32 902	9.95 686	6	53
	8	9.62 811	27	9.67 131	32	0.32 869	9.95 680	6	52
	9	9.62 838	27	9.67 163	33	0.32 837	9.95 674	6	51
	10	9.62 865	27	9.67 196	33	0.32 804	9.95 668	5	50
	11	9.62 892	26	9.67 229	33	0.32 771	9.95 663	6	49
	12	9.62 918	27	9.67 262	33	0.32 738	9.95 657	6	48
	13	9.62 945	27	9.67 295	32	0.32 705	9.95 651	6	47
	14	9.62 972	27	9.67 327	33	0.32 673	9.95 645	6	46
	15	9.62 999	27	9.67 360	33	0.32 640	9.95 639	6	45
	16	9.63 026	26	9.67 393	33	0.32 607	9.95 633	6	44
	17	9.63 052	27	9.67 426	32	0.32 574	9.95 627	6	43
	18	9.63 079	27	9.67 458	33	0.32 542	9.95 621	6	42
	19	9.63 106	27	9.67 491	33	0.32 509	9.95 615	6	41
	20	9.63 133	26	9.67 524	32	0.32 476	9.95 609	6	40
	21	9.63 159	27	9.67 556	33	0.32 444	9.95 603	6	39
	22	9.63 186	27	9.67 589	33	0.32 411	9.95 597	6	38
	23	9.63 213	26	9.67 622	32	0.32 378	9.95 591	6	37
	24	9.63 239	27	9.67 654	33	0.32 346	9.95 585	6	36
	25	9.63 266	26	9.67 687	32	0.32 313	9.95 579	6	35
	26	9.63 292	27	9.67 719	33	0.32 281	9.95 573	6	34
	27	9.63 319	26	9.67 752	33	0.32 248	9.95 567	6	33
	28	9.63 345	27	9.67 785	32	0.32 215	9.95 561	6	32
	29	9.63 372	26	9.67 817	33	0.32 183	9.95 555	6	31
	30	9.63 398	27	9.67 850	32	0.32 150	9.95 549	6	30
	31	9.63 425	26	9.67 882	33	0.32 118	9.95 543	6	29
	32	9.63 451	27	9.67 915	32	0.32 085	9.95 537	6	28
	33	9.63 478	26	9.67 947	33	0.32 053	9.95 531	6	27
	34	9.63 504	27	9.67 980	32	0.32 020	9.95 525	6	26
	35	9.63 531	26	9.68 012	32	0.31 988	9.95 519	6	25
	36	9.63 557	26	9.68 044	33	0.31 956	9.95 513	6	24
	37	9.63 583	27	9.68 077	32	0.31 923	9.95 507	7	23
	38	9.63 610	26	9.68 109	33	0.31 891	9.95 500	6	22
	39	9.63 636	26	9.68 142	32	0.31 858	9.95 494	6	21
	40	9.63 662	27	9.68 174	32	0.31 826	9.95 488	6	20
	41	9.63 689	26	9.68 206	33	0.31 794	9.95 482	6	19
	42	9.63 715	26	9.68 239	32	0.31 761	9.95 476	6	18
	43	9.63 741	26	9.68 271	32	0.31 729	9.95 470	6	17
	44	9.63 767	27	9.68 303	33	0.31 697	9.95 464	6	16
	45	9.63 794	26	9.68 336	32	0.31 664	9.95 458	6	15
	46	9.63 820	26	9.68 368	32	0.31 632	9.95 452	6	14
	47	9.63 846	26	9.68 400	32	0.31 600	9.95 446	6	13
	48	9.63 872	26	9.68 432	33	0.31 568	9.95 440	6	12
	49	9.63 898	26	9.68 465	32	0.31 535	9.95 434	7	11
	50	9.63 924	26	9.68 497	32	0.31 503	9.95 427	6	10
	51	9.63 950	26	9.68 529	32	0.31 471	9.95 421	6	9
	52	9.63 976	26	9.68 561	32	0.31 439	9.95 415	6	8
	53	9.64 002	26	9.68 593	33	0.31 407	9.95 409	6	7
	54	9.64 028	26	9.68 626	32	0.31 374	9.95 403	6	6
	55	9.64 054	26	9.68 658	32	0.31 342	9.95 397	6	5
	56	9.64 080	26	9.68 690	32	0.31 310	9.95 391	7	4
	57	9.64 106	26	9.68 722	32	0.31 278	9.95 384	6	3
	58	9.64 132	26	9.68 754	32	0.31 246	9.95 378	6	2
	59	9.64 158	26	9.68 786	32	0.31 214	9.95 372	6	1
	60	9.64 184		9.68 818		0.31 182	9.95 366		0
334°—, 154°— / 244°—, 64°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

PROP. PTS.

	33	32
1	3.3	3.2
2	6.6	6.4
3	9.9	9.6
4	13.2	12.8
5	16.5	16.0
6	19.8	19.2
7	23.1	22.4
8	26.4	25.6
9	29.7	28.8

	27
1	2.7
2	5.4
3	8.1
4	10.8
5	13.5
6	16.2
7	18.9
8	21.6
9	24.3

	26
1	2.6
2	5.2
3	7.8
4	10.4
5	13.0
6	15.6
7	18.2
8	20.8
9	23.4

	7
1	0.7
2	1.4
3	2.1
4	2.8
5	3.5
6	4.2
7	4.9
8	5.6
9	6.3

	6	5
1	0.6	0.5
2	1.2	1.0
3	1.8	1.5
4	2.4	2.0
5	3.0	2.5
6	3.6	3.0
7	4.2	3.5
8	4.8	4.0
9	5.4	4.5

26°..., 206°... / 116°..., 296°...	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.64 184	26	9.68 818	32	0.31 182	9.95 366	6	60
	1	9.64 210	26	9.68 850	32	0.31 150	9.95 360	6	59
	2	9.64 236	26	9.68 882	32	0.31 118	9.95 354	6	58
	3	9.64 262	26	9.68 914	32	0.31 086	9.95 348	7	57
	4	9.64 288	25	9.68 946	32	0.31 054	9.95 341	6	56
	5	9.64 313	26	9.68 978	32	0.31 022	9.95 335	6	55
	6	9.64 339	26	9.69 010	32	0.30 990	9.95 329	6	54
	7	9.64 365	26	9.69 042	32	0.30 958	9.95 323	6	53
	8	9.64 391	26	9.69 074	32	0.30 926	9.95 317	7	52
	9	9.64 417	25	9.69 106	32	0.30 894	9.95 310	6	51
	10	9.64 442	26	9.69 138	32	0.30 862	9.95 304	6	50
	11	9.64 468	26	9.69 170	32	0.30 830	9.95 298	6	49
	12	9.64 494	25	9.69 202	32	0.30 798	9.95 292	6	48
	13	9.64 519	26	9.69 234	32	0.30 766	9.95 286	7	47
	14	9.64 545	26	9.69 266	32	0.30 734	9.95 279	6	46
	15	9.64 571	25	9.69 298	31	0.30 702	9.95 273	6	45
	16	9.64 596	26	9.69 329	32	0.30 671	9.95 267	6	44
	17	9.64 622	25	9.69 361	32	0.30 639	9.95 261	7	43
	18	9.64 647	26	9.69 393	32	0.30 607	9.95 254	6	42
	19	9.64 673	25	9.69 425	32	0.30 575	9.95 248	6	41
	20	9.64 698	26	9.69 457	31	0.30 543	9.95 242	6	40
	21	9.64 724	25	9.69 488	32	0.30 512	9.95 236	7	39
	22	9.64 749	26	9.69 520	32	0.30 480	9.95 229	6	38
	23	9.64 775	25	9.69 552	32	0.30 448	9.95 223	6	37
	24	9.64 800	26	9.69 584	31	0.30 416	9.95 217	6	36
	25	9.64 826	25	9.69 615	32	0.30 385	9.95 211	7	35
	26	9.64 851	26	9.69 647	32	0.30 353	9.95 204	6	34
	27	9.64 877	25	9.69 679	31	0.30 321	9.95 198	6	33
	28	9.64 902	25	9.69 710	32	0.30 290	9.95 192	7	32
	29	9.64 927	26	9.69 742	32	0.30 258	9.95 185	6	31
	30	9.64 953	25	9.69 774	31	0.30 226	9.95 179	6	30
	31	9.64 978	25	9.69 805	32	0.30 195	9.95 173	6	29
	32	9.65 003	26	9.69 837	31	0.30 163	9.95 167	7	28
	33	9.65 029	25	9.69 868	32	0.30 132	9.95 160	6	27
	34	9.65 054	25	9.69 900	32	0.30 100	9.95 154	6	26
	35	9.65 079	25	9.69 932	31	0.30 068	9.95 148	7	25
	36	9.65 104	26	9.69 963	32	0.30 037	9.95 141	6	24
	37	9.65 130	25	9.69 995	31	0.30 005	9.95 135	6	23
	38	9.65 155	25	9.70 026	32	0.29 974	9.95 129	7	22
	39	9.65 180	25	9.70 058	31	0.29 942	9.95 122	6	21
	40	9.65 205	25	9.70 089	32	0.29 911	9.95 116	6	20
	41	9.65 230	25	9.70 121	31	0.29 879	9.95 110	7	19
	42	9.65 255	26	9.70 152	32	0.29 848	9.95 103	6	18
	43	9.65 281	25	9.70 184	31	0.29 816	9.95 097	7	17
	44	9.65 306	25	9.70 215	32	0.29 785	9.95 090	6	16
	45	9.65 331	25	9.70 247	31	0.29 753	9.95 084	6	15
	46	9.65 356	25	9.70 278	31	0.29 722	9.95 078	7	14
	47	9.65 381	25	9.70 309	32	0.29 691	9.95 071	6	13
	48	9.65 406	25	9.70 341	31	0.29 659	9.95 065	6	12
	49	9.65 431	25	9.70 372	32	0.29 628	9.95 059	7	11
	50	9.65 456	25	9.70 404	31	0.29 596	9.95 052	6	10
	51	9.65 481	25	9.70 435	31	0.29 565	9.95 046	7	9
	52	9.65 506	25	9.70 466	32	0.29 534	9.95 039	6	8
	53	9.65 531	25	9.70 498	31	0.29 502	9.95 033	6	7
	54	9.65 556	24	9.70 529	31	0.29 471	9.95 027	7	6
	55	9.65 580	25	9.70 560	32	0.29 440	9.95 020	6	5
	56	9.65 605	25	9.70 592	31	0.29 408	9.95 014	7	4
	57	9.65 630	25	9.70 623	31	0.29 377	9.95 007	6	3
	58	9.65 655	25	9.70 654	31	0.29 346	9.95 001	6	2
	59	9.65 680	25	9.70 685	32	0.29 315	9.94 995	7	1
	60	9.65 705		9.70 717		0.29 283	9.94 988		0
	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'

333°..., 153°... / 243°..., 63°...

PROP. PTS.

	32	31
1	3.2	3.1
2	6.4	6.2
3	9.6	9.3
4	12.8	12.4
5	16.0	15.5
6	19.2	18.6
7	22.4	21.7
8	25.6	24.8
9	28.8	27.9

	26
1	2.6
2	5.2
3	7.8
4	10.4
5	13.0
6	15.6
7	18.2
8	20.8
9	23.4

	25
1	2.5
2	5.0
3	7.5
4	10.0
5	12.5
6	15.0
7	17.5
8	20.0
9	22.5

	24
1	2.4
2	4.8
3	7.2
4	9.6
5	12.0
6	14.4
7	16.8
8	19.2
9	21.6

	7	6
1	0.7	0.6
2	1.4	1.2
3	2.1	1.8
4	2.8	2.4
5	3.5	3.0
6	4.2	3.6
7	4.9	4.2
8	5.6	4.8
9	6.3	5.4

27°__, 207°__	'	L SIN	D	L TAN	CD	L COT	L COS	D	
117°__, 297°__		L COS		L COT		L TAN	L SIN		
	0	9.65 705	24	9.70 717	31	0.29 283	9.94 988	6	60
	1	9.65 729	25	9.70 748	31	0.29 252	9.94 982	7	59
	2	9.65 754	25	9.70 779	31	0.29 221	9.94 975	6	58
	3	9.65 779	25	9.70 810	31	0.29 190	9.94 969	7	57
	4	9.65 804	24	9.70 841	32	0.29 159	9.94 962	6	56
	5	9.65 828	25	9.70 873	31	0.29 127	9.94 956	7	55
	6	9.65 853	25	9.70 904	31	0.29 096	9.94 949	6	54
	7	9.65 878	24	9.70 935	31	0.29 065	9.94 943	7	53
	8	9.65 902	25	9.70 966	31	0.29 034	9.94 936	6	52
	9	9.65 927	25	9.70 997	31	0.29 003	9.94 930	7	51
	10	9.65 952	24	9.71 028	31	0.28 972	9.94 923	6	50
	11	9.65 976	25	9.71 059	31	0.28 941	9.94 917	6	49
	12	9.66 001	24	9.71 090	31	0.28 910	9.94 911	7	48
	13	9.66 025	25	9.71 121	32	0.28 879	9.94 904	6	47
	14	9.66 050	25	9.71 153	31	0.28 847	9.94 898	7	46
	15	9.66 075	24	9.71 184	31	0.28 816	9.94 891	6	45
	16	9.66 099	25	9.71 215	31	0.28 785	9.94 885	7	44
	17	9.66 124	24	9.71 246	31	0.28 754	9.94 878	7	43
	18	9.66 148	25	9.71 277	31	0.28 723	9.94 871	6	42
	19	9.66 173	24	9.71 308	31	0.28 692	9.94 865	7	41
	20	9.66 197	24	9.71 339	31	0.28 661	9.94 858	6	40
	21	9.66 221	25	9.71 370	31	0.28 630	9.94 852	7	39
	22	9.66 246	24	9.71 401	30	0.28 599	9.94 845	6	38
	23	9.66 270	25	9.71 431	31	0.28 569	9.94 839	7	37
	24	9.66 295	24	9.71 462	31	0.28 538	9.94 832	6	36
	25	9.66 319	24	9.71 493	31	0.28 507	9.94 826	7	35
	26	9.66 343	25	9.71 524	31	0.28 476	9.94 919	6	34
	27	9.66 368	24	9.71 555	31	0.28 445	9.94 813	7	33
	28	9.66 392	24	9.71 586	31	0.28 414	9.94 806	7	32
	29	9.66 416	25	9.71 617	31	0.28 383	9.94 799	6	31
	30	9.66 441	24	9.71 648	31	0.28 352	9.94 793	7	30
	31	9.66 465	24	9.71 679	30	0.28 321	9.94 786	6	29
	32	9.66 489	24	9.71 709	31	0.28 291	9.94 780	7	28
	33	9.66 513	24	9.71 740	31	0.28 260	9.94 773	6	27
	34	9.66 537	25	9.71 771	31	0.28 229	9.94 767	7	26
	35	9.66 562	24	9.71 802	31	0.28 198	9.94 760	7	25
	36	9.66 586	24	9.71 833	30	0.28 167	9.94 753	6	24
	37	9.66 610	24	9.71 863	31	0.28 137	9.94 747	7	23
	38	9.66 634	24	9.71 894	31	0.28 106	9.94 740	6	22
	39	9.66 658	24	9.71 925	30	0.28 075	9.94 734	7	21
	40	9.66 682	24	9.71 955	31	0.28 045	9.94 727	7	20
	41	9.66 706	25	9.71 986	31	0.28 014	9.94 720	6	19
	42	9.66 731	24	9.72 017	31	0.27 983	9.94 714	7	18
	43	9.66 755	24	9.72 048	30	0.27 952	9.94 707	7	17
	44	9.66 779	24	9.72 078	31	0.27 922	9.94 700	6	16
	45	9.66 803	24	9.72 109	31	0.27 891	9.94 694	7	15
	46	9.66 827	24	9.72 140	30	0.27 860	9.94 687	7	14
	47	9.66 851	24	9.72 170	31	0.27 830	9.94 680	6	13
	48	9.66 875	24	9.72 201	30	0.27 799	9.94 674	7	12
	49	9.66 899	23	9.72 231	31	0.27 769	9.94 667	7	11
	50	9.66 922	24	9.72 262	31	0.27 738	9.94 660	6	10
	51	9.66 946	24	9.72 293	30	0.27 707	9.94 654	7	9
	52	9.66 970	24	9.72 323	31	0.27 677	9.94 647	7	8
	53	9.66 994	24	9.72 354	30	0.27 646	9.94 640	6	7
	54	9.67 018	24	9.72 384	31	0.27 616	9.94 634	7	6
	55	9.67 042	24	9.72 415	30	0.27 585	9.94 627	7	5
	56	9.67 066	24	9.72 445	31	0.27 555	9.94 620	6	4
	57	9.67 090	23	9.72 476	30	0.27 524	9.94 614	7	3
	58	9.67 113	24	9.72 506	31	0.27 494	9.94 607	7	2
	59	9.67 137	24	9.72 537	30	0.27 463	9.94 600	7	1
	60	9.67 161		9.72 567		0.27 433	9.94 593		0
		L SIN	D	L TAN	CD	L COT	L COS	D	'
		L COS		L COT		L TAN	L SIN		
332°__, 153°__									
242°__, 62°__									

PROP. PTS.

	32	31
1	3.2	3.1
2	6.4	6.2
3	9.6	9.3
4	12.8	12.4
5	16.0	15.5
6	19.2	18.6
7	22.4	21.7
8	25.6	24.8
9	28.8	27.9

	30
1	3.0
2	6.0
3	9.0
4	12.0
5	15.0
6	18.0
7	21.0
8	24.0
9	27.0

	25	24
1	2.5	2.4
2	5.0	4.3
3	7.5	7.2
4	10.0	9.6
5	12.5	12.0
6	15.0	14.4
7	17.5	16.8
8	20.0	19.2
9	22.5	21.6

	23
1	2.3
2	4.6
3	6.9
4	9.2
5	11.5
6	13.8
7	16.1
8	18.4
9	20.7

	7	6
1	0.7	0.6
2	1.4	1.2
3	2.1	1.8
4	2.8	2.4
5	3.5	3.0
6	4.2	3.6
7	4.9	4.2
8	5.6	4.8
9	6.3	5.4

28°__, 208°__	′	L SIN	D	L TAN	CD	L COT	L COS	D	
118°__, 298°__		L COS		L COT		L TAN	L SIN		
	0	9.67 161	24	9.72 567	31	0.27 433	9.94 593	6	60
	1	9.67 185	23	9.72 598	30	0.27 402	9.94 587	7	59
	2	9.67 208	24	9.72 628	31	0.27 372	9.94 580	7	58
	3	9.67 232	24	9.72 659	30	0.27 341	9.94 573	6	57
	4	9.67 256	24	9.72 689	31	0.27 311	9.94 567	7	56
	5	9.67 280	23	9.72 720	30	0.27 280	9.94 560	7	55
	6	9.67 303	24	9.72 750	30	0.27 250	9.94 553	7	54
	7	9.67 327	23	9.72 780	31	0.27 220	9.94 546	6	53
	8	9.67 350	24	9.72 811	30	0.27 189	9.94 540	7	52
	9	9.67 374	24	9.72 841	31	0.27 159	9.94 533	7	51
	10	9.67 398	23	9.72 872	30	0.27 128	9.94 526	7	50
	11	9.67 421	24	9.72 902	30	0.27 098	9.94 519	6	49
	12	9.67 445	23	9.72 932	31	0.27 068	9.94 513	7	48
	13	9.67 468	24	9.72 963	30	0.27 037	9.94 506	7	47
	14	9.67 492	23	9.72 993	30	0.27 007	9.94 499	7	46
	15	9.67 515	24	9.73 023	31	0.26 977	9.94 492	7	45
	16	9.67 539	23	9.73 054	30	0.26 946	9.94 485	6	44
	17	9.67 562	24	9.73 084	30	0.26 916	9.94 479	7	43
	18	9.67 586	23	9.73 114	30	0.26 886	9.94 472	7	42
	19	9.67 609	24	9.73 144	31	0.26 856	9.94 465	7	41
	20	9.67 633	23	9.73 175	30	0.26 825	9.94 458	7	40
	21	9.67 656	24	9.73 205	30	0.26 795	9.94 451	6	39
	22	9.67 680	23	9.73 235	30	0.26 765	9.94 445	7	38
	23	9.67 703	23	9.73 265	30	0.26 735	9.94 438	7	37
	24	9.67 726	24	9.73 295	31	0.26 705	9.94 431	7	36
	25	9.67 750	23	9.73 326	30	0.26 674	9.94 424	7	35
	26	9.67 773	23	9.73 356	30	0.26 644	9.94 417	7	34
	27	9.67 796	24	9.73 386	30	0.26 614	9.94 410	6	33
	28	9.67 820	23	9.73 416	30	0.26 584	9.94 404	7	32
	29	9.67 843	23	9.73 446	30	0.26 554	9.94 397	7	31
	30	9.67 866	24	9.73 476	31	0.26 524	9.94 390	7	30
	31	9.67 890	23	9.73 507	30	0.26 493	9.94 383	7	29
	32	9.67 913	23	9.73 537	30	0.26 463	9.94 376	7	28
	33	9.67 936	23	9.73 567	30	0.26 433	9.94 369	7	27
	34	9.67 959	23	9.73 597	30	0.26 403	9.94 362	7	26
	35	9.67 982	24	9.73 627	30	0.26 373	9.94 355	6	25
	36	9.68 006	23	9.73 657	30	0.26 343	9.94 349	7	24
	37	9.68 029	23	9.73 687	30	0.26 313	9.94 342	7	23
	38	9.68 052	23	9.73 717	30	0.26 283	9.94 335	7	22
	39	9.68 075	23	9.73 747	30	0.26 253	9.94 328	7	21
	40	9.68 098	23	9.73 777	30	0.26 223	9.94 321	7	20
	41	9.68 121	23	9.73 807	30	0.26 193	9.94 314	7	19
	42	9.68 144	23	9.73 837	30	0.26 163	9.94 307	7	18
	43	9.68 167	23	9.73 867	30	0.26 133	9.94 300	7	17
	44	9.68 190	23	9.73 897	30	0.26 103	9.94 293	7	16
	45	9.68 213	24	9.73 927	30	0.26 073	9.94 286	7	15
	46	9.68 237	23	9.73 957	30	0.26 043	9.94 279	6	14
	47	9.68 260	23	9.73 987	30	0.26 013	9.94 273	7	13
	48	9.68 283	22	9.74 017	30	0.25 983	9.94 266	7	12
	49	9.68 305	23	9.74 047	30	0.25 953	9.94 259	7	11
	50	9.68 328	23	9.74 077	30	0.25 923	9.94 252	7	10
	51	9.68 351	23	9.74 107	30	0.25 893	9.94 245	7	9
	52	9.68 374	23	9.74 137	29	0.25 863	9.94 238	7	8
	53	9.68 397	23	9.74 166	30	0.25 834	9.94 231	7	7
	54	9.68 420	23	9.74 196	30	0.25 804	9.94 224	7	6
	55	9.68 443	23	9.74 226	30	0.25 774	9.94 217	7	5
	56	9.68 466	23	9.74 256	30	0.25 744	9.94 210	7	4
	57	9.68 489	23	9.74 286	30	0.25 714	9.94 203	7	3
	58	9.68 512	22	9.74 316	29	0.25 684	9.94 196	7	2
	59	9.68 534	23	9.74 345	30	0.25 655	9.94 189	7	1
	60	9.68 557		9.74 375		0.25 625	9.94 182		0
		L SIN	D	L TAN	CD	L COT	L COS	D	′
		L COS		L COT		L TAN	L SIN		

331°__, 151°__
241°__, 61°__

PROP. PTS.

	31	30
1	3.1	3.0
2	6.2	6.0
3	9.3	9.0
4	12.4	12.0
5	15.5	15.0
6	18.6	18.0
7	21.7	21.0
8	24.8	24.0
9	27.9	27.0

	29
1	2.9
2	5.8
3	8.7
4	11.6
5	14.5
6	17.4
7	20.3
8	23.2
9	26.1

	24	23
1	2.4	2.3
2	4.8	4.6
3	7.2	6.9
4	9.6	9.2
5	12.0	11.5
6	14.4	13.8
7	16.8	16.1
8	19.2	18.4
9	21.6	20.7

	22
1	2.2
2	4.4
3	6.6
4	8.8
5	11.0
6	13.2
7	15.4
8	17.6
9	19.8

	7	6
1	0.7	0.6
2	1.4	1.2
3	2.1	1.8
4	2.8	2.4
5	3.5	3.0
6	4.2	3.6
7	4.9	4.2
8	5.6	4.8
9	6.3	5.4

29°—, 209°— / 119°—, 299°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.68 557	23	9.74 375	30	0.25 625	9.94 182	7	60
	1	9.68 580	23	9.74 405	30	0.25 595	9.94 175	7	59
	2	9.68 603	22	9.74 435	30	0.25 565	9.94 168	7	58
	3	9.68 625	23	9.74 465	29	0.25 535	9.94 161	7	57
	4	9.68 648	23	9.74 494	30	0.25 506	9.94 154	7	56
	5	9.68 671	23	9.74 524	30	0.25 476	9.94 147	7	55
	6	9.68 694	22	9.74 554	29	0.25 446	9.94 140	7	54
	7	9.68 716	23	9.74 583	30	0.25 417	9.94 133	7	53
	8	9.68 739	23	9.74 613	30	0.25 387	9.94 126	7	52
	9	9.68 762	22	9.74 643	30	0.25 357	9.94 119	7	51
	10	9.68 784	23	9.74 673	29	0.25 327	9.94 112	7	50
	11	9.68 807	22	9.74 702	30	0.25 298	9.94 105	7	49
	12	9.68 829	23	9.74 732	30	0.25 268	9.94 098	8	48
	13	9.68 852	23	9.74 762	29	0.25 238	9.94 090	7	47
	14	9.68 875	22	9.74 791	30	0.25 209	9.94 083	7	46
	15	9.68 897	23	9.74 821	30	0.25 179	9.94 076	7	45
	16	9.68 920	22	9.74 851	29	0.25 149	9.94 069	7	44
	17	9.68 942	23	9.74 880	30	0.25 120	9.94 062	7	43
	18	9.68 965	22	9.74 910	29	0.25 090	9.94 055	7	42
	19	9.68 987	23	9.74 939	30	0.25 061	9.94 048	7	41
	20	9.69 010	22	9.74 969	29	0.25 031	9.94 041	7	40
	21	9.69 032	23	9.74 998	30	0.25 002	9.94 034	7	39
	22	9.69 055	22	9.75 028	30	0.24 972	9.94 027	7	38
	23	9.69 077	23	9.75 058	29	0.24 942	9.94 020	8	37
	24	9.69 100	22	9.75 087	30	0.24 913	9.94 012	7	36
	25	9.69 122	22	9.75 117	29	0.24 883	9.94 005	7	35
	26	9.69 144	23	9.75 146	30	0.24 854	9.93 998	7	34
	27	9.69 167	22	9.75 176	29	0.24 824	9.93 991	7	33
	28	9.69 189	23	9.75 205	30	0.24 795	9.93 984	7	32
	29	9.69 212	22	9.75 235	29	0.24 765	9.93 977	7	31
	30	9.69 234	22	9.75 264	30	0.24 736	9.93 970	7	30
	31	9.69 256	23	9.75 294	29	0.24 706	9.93 963	8	29
	32	9.69 279	22	9.75 323	30	0.24 677	9.93 955	7	28
	33	9.69 301	22	9.75 353	29	0.24 647	9.93 948	7	27
	34	9.69 323	22	9.75 382	29	0.24 618	9.93 941	7	26
	35	9.69 345	23	9.75 411	30	0.24 589	9.93 934	7	25
	36	9.69 368	22	9.75 441	29	0.24 559	9.93 927	7	24
	37	9.69 390	22	9.75 470	30	0.24 530	9.93 920	8	23
	38	9.69 412	22	9.75 500	29	0.24 500	9.93 912	7	22
	39	9.69 434	22	9.75 529	29	0.24 471	9.93 905	7	21
	40	9.69 456	23	9.75 558	30	0.24 442	9.93 898	7	20
	41	9.69 479	22	9.75 588	29	0.24 412	9.93 891	7	19
	42	9.69 501	22	9.75 617	30	0.24 383	9.93 884	8	18
	43	9.69 523	22	9.75 647	29	0.24 353	9.93 876	7	17
	44	9.69 545	22	9.75 676	29	0.24 324	9.93 869	7	16
	45	9.69 567	22	9.75 705	30	0.24 295	9.93 862	7	15
	46	9.69 589	22	9.75 735	29	0.24 265	9.93 855	8	14
	47	9.69 611	22	9.75 764	29	0.24 236	9.93 847	7	13
	48	9.69 633	22	9.75 793	29	0.24 207	9.93 840	7	12
	49	9.69 655	22	9.75 822	30	0.24 178	9.93 833	7	11
	50	9.69 677	22	9.75 852	29	0.24 148	9.93 826	7	10
	51	9.69 699	22	9.75 881	29	0.24 119	9.93 819	8	9
	52	9.69 721	22	9.75 910	29	0.24 090	9.93 811	7	8
	53	9.69 743	22	9.75 939	30	0.24 061	9.93 804	7	7
	54	9.69 765	22	9.75 969	29	0.24 031	9.93 797	8	6
	55	9.69 787	22	9.75 998	29	0.24 002	9.93 789	7	5
	56	9.69 809	22	9.76 027	29	0.23 973	9.93 782	7	4
	57	9.69 831	22	9.76 056	30	0.23 944	9.93 775	7	3
	58	9.69 853	22	9.76 086	29	0.23 914	9.93 768	8	2
	59	9.69 875	22	9.76 115	29	0.23 885	9.93 760	7	1
	60	9.69 897		9.76 144		0.23 856	9.93 753		0
330°—, 150°— / 240°—, 60°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'

PROP. PTS.

	30	29	23	22	8	7
1	3.0	2.9	2.3	2.2	0.8	0.7
2	6.0	5.8	4.6	4.4	1.6	1.4
3	9.0	8.7	6.9	6.6	2.4	2.1
4	12.0	11.6	9.2	8.8	3.2	2.8
5	15.0	14.5	11.5	11.0	4.0	3.5
6	18.0	17.4	13.8	13.2	4.8	4.2
7	21.0	20.3	16.1	15.4	5.6	4.9
8	24.0	23.2	18.4	17.6	6.4	5.6
9	27.0	26.1	20.7	19.8	7.4	6.3

30°__, 210°__ / 120°__, 300°__	'	L SIN	D	L TAN	CD	L COT	L COS	D	
		L COS		L COT		L TAN	L SIN		
	0	9.69 897	22	9.76 144	29	0.23 856	9.93 753	7	60
	1	9.69 919	22	9.76 173	29	0.23 827	9.93 746	8	59
	2	9.69 941	22	9.76 202	29	0.23 798	9.93 738	7	58
	3	9.69 963	21	9.76 231	30	0.23 769	9.93 731	7	57
	4	9.69 984	22	9.76 261	29	0.23 739	9.93 724	7	56
	5	9.70 006	22	9.76 290	29	0.23 710	9.93 717	8	55
	6	9.70 028	22	9.76 319	29	0.23 681	9.93 709	7	54
	7	9.70 050	22	9.76 348	29	0.23 652	9.93 702	7	53
	8	9.70 072	21	9.76 377	29	0.23 623	9.93 695	8	52
	9	9.70 093	22	9.76 406	29	0.23 594	9.93 687	7	51
	10	9.70 115	22	9.76 435	29	0.23 565	9.93 680	7	50
	11	9.70 137	22	9.76 464	29	0.23 536	9.93 673	8	49
	12	9.70 159	21	9.76 493	29	0.23 507	9.93 665	7	48
	13	9.70 180	22	9.76 522	29	0.23 478	9.93 658	8	47
	14	9.70 202	22	9.76 551	29	0.23 449	9.93 650	7	46
	15	9.70 224	21	9.76 580	29	0.23 420	9.93 643	7	45
	16	9.70 245	22	9.76 609	30	0.23 391	9.93 636	8	44
	17	9.70 267	21	9.76 639	29	0.23 361	9.93 628	7	43
	18	9.70 288	22	9.76 668	29	0.23 332	9.93 621	7	42
	19	9.70 310	22	9.76 697	28	0.23 303	9.93 614	8	41
	20	9.70 332	21	9.76 725	29	0.23 275	9.93 606	7	40
	21	9.70 353	22	9.76 754	29	0.23 246	9.93 599	8	39
	22	9.70 375	21	9.76 783	29	0.23 217	9.93 591	7	38
	23	9.70 396	22	9.76 812	29	0.23 188	9.93 584	7	37
	24	9.70 418	21	9.76 841	29	0.23 159	9.93 577	8	36
	25	9.70 439	22	9.76 870	29	0.23 130	9.93 569	7	35
	26	9.70 461	21	9.76 899	29	0.23 101	9.93 562	8	34
	27	9.70 482	22	9.76 928	29	0.23 072	9.93 554	7	33
	28	9.70 504	21	9.76 957	29	0.23 043	9.93 547	8	32
	29	9.70 525	22	9.76 986	29	0.23 014	9.93 539	7	31
	30	9.70 547	21	9.77 015	29	0.22 985	9.93 532	7	30
	31	9.70 568	22	9.77 044	29	0.22 956	9.93 525	8	29
	32	9.70 590	21	9.77 073	28	0.22 927	9.93 517	7	28
	33	9.70 611	22	9.77 101	29	0.22 899	9.93 510	8	27
	34	9.70 633	21	9.77 130	29	0.22 870	9.93 502	7	26
	35	9.70 654	21	9.77 159	29	0.22 841	9.93 495	8	25
	36	9.70 675	22	9.77 188	29	0.22 812	9.93 487	7	24
	37	9.70 697	21	9.77 217	29	0.22 783	9.93 480	8	23
	38	9.70 718	21	9.77 246	28	0.22 754	9.93 472	7	22
	39	9.70 739	22	9.77 274	29	0.22 726	9.93 465	8	21
	40	9.70 761	21	9.77 303	29	0.22 697	9.93 457	7	20
	41	9.70 782	21	9.77 332	29	0.22 668	9.93 450	8	19
	42	9.70 803	21	9.77 361	29	0.22 639	9.93 442	7	18
	43	9.70 824	22	9.77 390	28	0.22 610	9.93 435	8	17
	44	9.70 846	21	9.77 418	29	0.22 582	9.93 427	7	16
	45	9.70 867	21	9.77 447	29	0.22 553	9.93 420	8	15
	46	9.70 888	21	9.77 476	29	0.22 524	9.93 412	7	14
	47	9.70 909	22	9.77 505	28	0.22 495	9.93 405	8	13
	48	9.70 931	21	9.77 533	29	0.22 467	9.93 397	7	12
	49	9.70 952	21	9.77 562	29	0.22 438	9.93 390	8	11
	50	9.70 973	21	9.77 591	28	0.22 409	9.93 382	7	10
	51	9.70 994	21	9.77 619	29	0.22 381	9.93 375	8	9
	52	9.71 015	21	9.77 648	29	0.22 352	9.93 367	7	8
	53	9.71 036	22	9.77 677	29	0.22 323	9.93 360	8	7
	54	9.71 058	21	9.77 706	28	0.22 294	9.93 352	8	6
	55	9.71 079	21	9.77 734	29	0.22 266	9.93 344	7	5
	56	9.71 100	21	9.77 763	28	0.22 237	9.93 337	8	4
	57	9.71 121	21	9.77 791	29	0.22 209	9.93 329	7	3
	58	9.71 142	21	9.77 820	29	0.22 180	9.93 322	8	2
	59	9.71 163	21	9.77 849	28	0.22 151	9.93 314	7	1
	60	9.71 184		9.77 877		0.22 123	9.93 307		0
		L SIN	D	L TAN	CD	L COT	L COS	D	329°__, 149°__
		L COS		L COT		L TAN	L SIN		239°__, 59°__

PROP. PTS.

	30	29
1	3.0	2.9
2	6.0	5.8
3	9.0	8.7
4	12.0	11.6
5	15.0	14.5
6	18.0	17.4
7	21.0	20.3
8	24.0	23.2
9	27.0	26.1

	28
1	2.8
2	5.6
3	8.4
4	11.2
5	14.0
6	16.8
7	19.6
8	22.4
9	25.2

	22
1	2.2
2	4.4
3	6.6
4	8.8
5	11.0
6	13.2
7	15.4
8	17.6
9	19.8

	21
1	2.1
2	4.2
3	6.3
4	8.4
5	10.5
6	12.6
7	14.7
8	16.8
9	18.9

	8	7
1	0.8	0.7
2	1.6	1.4
3	2.4	2.1
4	3.2	2.8
5	4.0	3.5
6	4.8	4.2
7	5.6	4.9
8	6.4	5.6
9	7.2	6.3

31°—, 211°— / 121°—, 301°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.71 184	21	9.77 877	29	0.22 123	9.93 307	8	60
	1	9.71 205	21	9.77 906	29	0.22 094	9.93 299	8	59
	2	9.71 226	21	9.77 935	28	0.22 065	9.93 291	7	58
	3	9.71 247	21	9.77 963	29	0.22 037	9.93 284	8	57
	4	9.71 268	21	9.77 992	28	0.22 008	9.93 276	7	56
	5	9.71 289	21	9.78 020	29	0.21 980	9.93 269	8	55
	6	9.71 310	21	9.78 049	28	0.21 951	9.93 261	8	54
	7	9.71 331	21	9.78 077	29	0.21 923	9.93 253	7	53
	8	9.71 352	21	9.78 106	29	0.21 894	9.93 246	8	52
	9	9.71 373	20	9.78 135	28	0.21 865	9.93 238	8	51
	10	9.71 393	21	9.78 163	29	0.21 837	9.93 230	7	50
	11	9.71 414	21	9.78 192	28	0.21 808	9.93 223	8	49
	12	9.71 435	21	9.78 220	29	0.21 780	9.93 215	8	48
	13	9.71 456	21	9.78 249	28	0.21 751	9.93 207	7	47
	14	9.71 477	21	9.78 277	29	0.21 723	9.93 200	8	46
	15	9.71 498	21	9.78 306	28	0.21 694	9.93 192	8	45
	16	9.71 519	20	9.78 334	29	0.21 666	9.93 184	7	44
	17	9.71 539	21	9.78 363	28	0.21 637	9.93 177	8	43
	18	9.71 560	21	9.78 391	28	0.21 609	9.93 169	8	42
	19	9.71 581	21	9.78 419	29	0.21 581	9.93 161	7	41
	20	9.71 602	20	9.78 448	28	0.21 552	9.93 154	8	40
	21	9.71 622	21	9.78 476	29	0.21 524	9.93 146	8	39
	22	9.71 643	21	9.78 505	28	0.21 495	9.93 138	7	38
	23	9.71 664	21	9.78 533	29	0.21 467	9.93 131	8	37
	24	9.71 685	20	9.78 562	28	0.21 438	9.93 123	8	36
	25	9.71 705	21	9.78 590	28	0.21 410	9.93 115	7	35
	26	9.71 726	21	9.78 618	29	0.21 382	9.93 108	8	34
	27	9.71 747	20	9.78 647	28	0.21 353	9.93 100	8	33
	28	9.71 767	21	9.78 675	29	0.21 325	9.93 092	8	32
	29	9.71 788	21	9.78 704	28	0.21 296	9.93 084	7	31
	30	9.71 809	20	9.78 732	28	0.21 268	9.93 077	8	30
	31	9.71 829	21	9.78 760	29	0.21 240	9.93 069	8	29
	32	9.71 850	20	9.78 789	28	0.21 211	9.93 061	8	28
	33	9.71 870	21	9.78 817	28	0.21 183	9.93 053	7	27
	34	9.71 891	20	9.78 845	29	0.21 155	9.93 046	8	26
	35	9.71 911	21	9.78 874	28	0.21 126	9.93 038	8	25
	36	9.71 932	20	9.78 902	28	0.21 098	9.93 030	8	24
	37	9.71 952	21	9.78 930	29	0.21 070	9.93 022	8	23
	38	9.71 973	21	9.78 959	28	0.21 041	9.93 014	7	22
	39	9.71 994	20	9.78 987	28	0.21 013	9.93 007	8	21
	40	9.72 014	20	9.79 015	28	0.20 985	9.92 999	8	20
	41	9.72 034	21	9.79 043	29	0.20 957	9.92 991	8	19
	42	9.72 055	20	9.79 072	28	0.20 928	9.92 983	7	18
	43	9.72 075	21	9.79 100	28	0.20 900	9.92 976	8	17
	44	9.72 096	20	9.79 128	28	0.20 872	9.92 968	8	16
	45	9.72 116	21	9.79 156	29	0.20 844	9.92 960	8	15
	46	9.72 137	20	9.79 185	28	0.20 815	9.92 952	8	14
	47	9.72 157	20	9.79 213	28	0.20 787	9.92 944	8	13
	48	9.72 177	21	9.79 241	28	0.20 759	9.92 936	7	12
	49	9.72 198	20	9.79 269	28	0.20 731	9.92 929	8	11
	50	9.72 218	20	9.79 297	29	0.20 703	9.92 921	8	10
	51	9.72 238	21	9.79 326	28	0.20 674	9.92 913	8	9
	52	9.72 259	20	9.79 354	28	0.20 646	9.92 905	8	8
	53	9.72 279	20	9.79 382	28	0.20 618	9.92 897	8	7
	54	9.72 299	21	9.79 410	28	0.20 590	9.92 889	8	6
	55	9.72 320	20	9.79 438	28	0.20 562	9.92 881	7	5
	56	9.72 340	20	9.79 466	29	0.20 534	9.92 874	8	4
	57	9.72 360	21	9.79 495	28	0.20 505	9.92 866	8	3
	58	9.72 381	20	9.79 523	28	0.20 477	9.92 858	8	2
	59	9.72 401	20	9.79 551	28	0.20 449	9.92 850	8	1
	60	9.72 421		9.79 579		0.20 421	9.92 842		0
328°—, 148°— / 238°—, 58°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′

PROP. PTS.

	29	28	21	20	8	7
1	2.9	2.8	2.1	2.0	0.8	0.7
2	5.8	5.6	4.2	4.0	1.6	1.4
3	8.7	8.4	6.3	6.0	2.4	2.1
4	11.6	11.2	8.4	8.0	3.2	2.8
5	14.5	14.0	10.5	10.0	4.0	3.5
6	17.4	16.8	12.6	12.0	4.8	4.2
7	20.3	19.6	14.7	14.0	5.6	4.9
8	23.2	22.4	16.8	16.0	6.4	5.6
9	26.1	25.2	18.9	18.0	7.2	6.3

32°—, 212°— / 122°—, 302°—	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D		PROP. PTS.
0	9.72 421	20	9.79 579	28	0.20 421	9.92 842	8	60	
1	9.72 441	20	9.79 607	28	0.20 393	9.92 834	8	59	
2	9.72 461	21	9.79 635	28	0.20 365	9.92 826	8	58	
3	9.72 482	20	9.79 663	28	0.20 337	9.92 818	8	57	
4	9.72 502	20	9.79 691	28	0.20 309	9.92 810	7	56	
5	9.72 522	20	9.79 719	28	0.20 281	9.92 803	8	55	
6	9.72 542	20	9.79 747	29	0.20 253	9.92 795	8	54	
7	9.72 562	20	9.79 776	28	0.20 224	9.92 787	8	53	
8	9.72 582	20	9.79 804	28	0.20 196	9.92 779	8	52	
9	9.72 602	20	9.79 832	28	0.20 168	9.92 771	8	51	
10	9.72 622	21	9.79 860	28	0.20 140	9.92 763	8	50	
11	9.72 643	20	9.79 888	28	0.20 112	9.92 755	8	49	
12	9.72 663	20	9.79 916	28	0.20 084	9.92 747	8	48	
13	9.72 683	20	9.79 944	28	0.20 056	9.92 739	8	47	
14	9.72 703	20	9.79 972	28	0.20 028	9.92 731	8	46	
15	9.72 723	20	9.80 000	28	0.20 000	9.92 723	8	45	
16	9.72 743	20	9.80 028	28	0.19 972	9.92 715	8	44	
17	9.72 763	20	9.80 056	28	0.19 944	9.92 707	8	43	
18	9.72 783	20	9.80 084	28	0.19 916	9.92 699	8	42	
19	9.72 803	20	9.80 112	28	0.19 888	9.92 691	8	41	
20	9.72 823	20	9.80 140	28	0.19 860	9.92 683	8	40	
21	9.72 843	20	9.80 168	27	0.19 832	9.92 675	8	39	
22	9.72 863	20	9.80 195	28	0.19 805	9.92 667	8	38	
23	9.72 883	19	9.80 223	28	0.19 777	9.92 659	8	37	
24	9.72 902	20	9.80 251	28	0.19 749	9.92 651	8	36	
25	9.72 922	20	9.80 279	28	0.19 721	9.92 643	8	35	
26	9.72 942	20	9.80 307	28	0.19 693	9.92 635	8	34	
27	9.72 962	20	9.80 335	28	0.19 665	9.92 627	8	33	
28	9.72 982	20	9.80 363	28	0.19 637	9.92 619	8	32	
29	9.73 002	20	9.80 391	28	0.19 609	9.92 611	8	31	
30	9.73 022	19	9.80 419	28	0.19 581	9.92 603	8	30	
31	9.73 041	20	9.80 447	27	0.19 553	9.92 595	8	29	
32	9.73 061	20	9.80 474	28	0.19 526	9.92 587	8	28	
33	9.73 081	20	9.80 502	28	0.19 498	9.92 579	8	27	
34	9.73 101	20	9.80 530	28	0.19 470	9.92 571	8	26	
35	9.73 121	19	9.80 558	28	0.19 442	9.92 563	8	25	
36	9.73 140	20	9.80 586	28	0.19 414	9.92 555	9	24	
37	9.73 160	20	9.80 614	28	0.19 386	9.92 546	8	23	
38	9.73 180	20	9.80 642	27	0.19 358	9.92 538	8	22	
39	9.73 200	19	9.80 669	28	0.19 331	9.92 530	8	21	
40	9.73 219	20	9.80 697	28	0.19 303	9.92 522	8	20	
41	9.73 239	20	9.80 725	28	0.19 275	9.92 514	8	19	
42	9.73 259	19	9.80 753	28	0.19 247	9.92 506	8	18	
43	9.73 278	20	9.80 781	27	0.19 219	9.92 498	8	17	
44	9.73 298	20	9.80 808	28	0.19 192	9.92 490	8	16	
45	9.73 318	19	9.80 836	28	0.19 164	9.92 482	9	15	
46	9.73 337	20	9.80 864	28	0.19 136	9.92 473	8	14	
47	9.73 357	20	9.80 892	27	0.19 108	9.92 465	8	13	
48	9.73 377	19	9.80 919	28	0.19 081	9.92 457	8	12	
49	9.73 396	20	9.80 947	28	0.19 053	9.92 449	8	11	
50	9.73 416	19	9.80 975	28	0.19 025	9.92 441	8	10	
51	9.73 435	20	9.81 003	27	0.18 997	9.92 433	8	9	
52	9.73 455	19	9.81 030	28	0.18 970	9.92 425	9	8	
53	9.73 474	20	9.81 058	28	0.18 942	9.92 416	8	7	
54	9.73 494	19	9.81 086	27	0.18 914	9.92 408	8	6	
55	9.73 513	20	9.81 113	28	0.18 887	9.92 400	8	5	
56	9.73 533	19	9.81 141	28	0.18 859	9.92 392	8	4	
57	9.73 552	20	9.81 169	27	0.18 831	9.92 384	8	3	
58	9.73 572	19	9.81 196	28	0.18 804	9.92 376	9	2	
59	9.73 591	20	9.81 224	28	0.18 776	9.92 367	8	1	
60	9.73 611		9.81 252		0.18 748	9.92 359		0	
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D		227°—, 147°— / 237°—, 57°—

PROP. PTS.

	29	28
1	2.9	2.8
2	5.8	5.6
3	8.7	8.4
4	11.6	11.2
5	14.5	14.0
6	17.4	16.8
7	20.3	19.6
8	23.2	22.4
9	26.1	25.2

	27
1	2.7
2	5.4
3	8.1
4	10.8
5	13.5
6	16.2
7	18.9
8	21.6
9	24.3

	21	20
1	2.1	2.0
2	4.2	4.0
3	6.3	6.0
4	8.4	8.0
5	10.5	10.0
6	12.6	12.0
7	14.7	14.0
8	16.8	16.0
9	18.9	18.0

	19	9
1	1.9	0.9
2	3.8	1.8
3	5.7	2.7
4	7.6	3.6
5	9.5	4.5
6	11.4	5.4
7	13.3	6.3
8	15.2	7.2
9	17.1	8.1

	8	7
1	0.8	0.7
2	1.6	1.4
3	2.4	2.1
4	3.2	2.8
5	4.0	3.5
6	4.8	4.2
7	5.6	4.9
8	6.4	5.6
9	7.2	6.3

33°—, 212°— / 123°—, 303°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.73 611	19	9.81 252	27	0.18 748	9.92 359	8	60
	1	9.73 630	20	9.81 279	28	0.18 721	9.92 351	8	59
	2	9.73 650	19	9.81 307	28	0.18 693	9.92 343	8	58
	3	9.73 669	20	9.81 335	27	0.18 665	9.92 335	9	57
	4	9.73 689	19	9.81 362	28	0.18 638	9.92 326	8	56
	5	9.73 708	19	9.81 390	28	0.18 610	9.92 318	8	55
	6	9.73 727	20	9.81 418	27	0.18 582	9.92 310	8	54
	7	9.73 747	19	9.81 445	28	0.18 555	9.92 302	9	53
	8	9.73 766	19	9.81 473	27	0.18 527	9.92 293	8	52
	9	9.73 785	20	9.81 500	28	0.18 500	9.92 285	8	51
	10	9.73 805	19	9.81 528	28	0.18 472	9.92 277	8	50
	11	9.73 824	19	9.81 556	27	0.18 444	9.92 269	9	49
	12	9.73 843	20	9.81 583	28	0.18 417	9.92 260	8	48
	13	9.73 863	19	9.81 611	27	0.18 389	9.92 252	8	47
	14	9.73 882	19	9.81 638	28	0.18 362	9.92 244	9	46
	15	9.73 901	20	9.81 666	27	0.18 334	9.92 235	8	45
	16	9.73 921	19	9.81 693	28	0.18 307	9.92 227	8	44
	17	9.73 940	19	9.81 721	27	0.18 279	9.92 219	8	43
	18	9.73 959	19	9.81 748	28	0.18 252	9.92 211	9	42
	19	9.73 978	19	9.81 776	27	0.18 224	9.92 202	8	41
	20	9.73 997	20	9.81 803	28	0.18 197	9.92 194	8	40
	21	9.74 017	19	9.81 831	27	0.18 169	9.92 186	9	39
	22	9.74 036	19	9.81 858	28	0.18 142	9.92 177	8	38
	23	9.74 055	19	9.81 886	27	0.18 114	9.92 169	8	37
	24	9.74 074	19	9.81 913	28	0.18 087	9.92 161	9	36
	25	9.74 093	20	9.81 941	27	0.18 059	9.92 152	8	35
	26	9.74 113	19	9.81 968	28	0.18 032	9.92 144	8	34
	27	9.74 132	19	9.81 996	27	0.18 004	9.92 136	9	33
	28	9.74 151	19	9.82 023	28	0.17 977	9.92 127	8	32
	29	9.74 170	19	9.82 051	27	0.17 949	9.92 119	8	31
	30	9.74 189	19	9.82 078	28	0.17 922	9.92 111	9	30
	31	9.74 208	19	9.82 106	27	0.17 894	9.92 102	8	29
	32	9.74 227	19	9.82 133	28	0.17 867	9.92 094	8	28
	33	9.74 246	19	9.82 161	27	0.17 839	9.92 086	9	27
	34	9.74 265	19	9.82 188	27	0.17 812	9.92 077	8	26
	35	9.74 284	19	9.82 215	28	0.17 785	9.92 069	9	25
	36	9.74 303	19	9.82 243	27	0.17 757	9.92 060	8	24
	37	9.74 322	19	9.82 270	28	0.17 730	9.92 052	8	23
	38	9.74 341	19	9.82 298	27	0.17 702	9.92 044	9	22
	39	9.74 360	19	9.82 325	27	0.17 675	9.92 035	8	21
	40	9.74 379	19	9.82 352	28	0.17 648	9.92 027	9	20
	41	9.74 398	19	9.82 380	27	0.17 620	9.92 018	8	19
	42	9.74 417	19	9.82 407	28	0.17 593	9.92 010	8	18
	43	9.74 436	19	9.82 435	27	0.17 565	9.92 002	9	17
	44	9.74 455	19	9.82 462	27	0.17 538	9.91 993	8	16
	45	9.74 474	19	9.82 489	28	0.17 511	9.91 985	9	15
	46	9.74 493	19	9.82 517	27	0.17 483	9.91 976	8	14
	47	9.74 512	19	9.82 544	27	0.17 456	9.91 968	9	13
	48	9.74 531	18	9.82 571	28	0.17 429	9.91 959	8	12
	49	9.74 549	19	9.82 599	27	0.17 401	9.91 951	9	11
	50	9.74 568	19	9.82 626	27	0.17 374	9.91 942	8	10
	51	9.74 587	19	9.82 653	28	0.17 347	9.91 934	9	9
	52	9.74 606	19	9.82 681	27	0.17 319	9.91 925	8	8
	53	9.74 625	19	9.82 708	27	0.17 292	9.91 917	9	7
	54	9.74 644	18	9.82 735	27	0.17 265	9.91 908	8	6
	55	9.74 662	19	9.82 762	28	0.17 238	9.91 900	9	5
	56	9.74 681	19	9.82 790	27	0.17 210	9.91 891	8	4
	57	9.74 700	19	9.82 817	27	0.17 183	9.91 883	9	3
	58	9.74 719	18	9.82 844	27	0.17 156	9.91 874	8	2
	59	9.74 737	19	9.82 871	28	0.17 129	9.91 866	9	1
	60	9.74 756		9.82 899		0.17 101	9.91 857		0
326°—, 146°— / 236°—, 56°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′

PROP. PTS.

	28	27
1	2.8	2.7
2	5.6	5.4
3	8.4	8.1
4	11.2	10.8
5	14.0	13.5
6	16.8	16.2
7	19.6	18.9
8	22.4	21.6
9	25.2	24.3

	20
1	2.0
2	4.0
3	6.0
4	8.0
5	10.0
6	12.0
7	14.0
8	16.0
9	18.0

	19
1	1.9
2	3.8
3	5.7
4	7.6
5	9.5
6	11.4
7	13.3
8	15.2
9	17.1

	18
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2

	9	8
1	0.9	0.8
2	1.8	1.6
3	2.7	2.4
4	3.6	3.2
5	4.5	4.0
6	5.4	4.8
7	6.3	5.6
8	7.2	6.4
9	8.1	7.2

34°—, 214°— / 124°—, 304°—	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.74 756	19	9.82 899	27	0.17 101	9.91 857	8	60
1	9.74 775	19	9.82 926	27	0.17 074	9.91 849	9	59
2	9.74 794	18	9.82 953	27	0.17 047	9.91 840	8	58
3	9.74 812	19	9.82 980	28	0.17 020	9.91 832	9	57
4	9.74 831	19	9.83 008	27	0.16 992	9.91 823	8	56
5	9.74 850	18	9.83 035	27	0.16 956	9.91 815	9	55
6	9.74 868	19	9.83 062	27	0.16 938	9.91 806	8	54
7	9.74 887	19	9.83 089	28	0.16 911	9.91 798	9	53
8	9.74 906	18	9.83 117	27	0.16 883	9.91 789	8	52
9	9.74 924	19	9.83 144	27	0.16 856	9.91 781	9	51
10	9.74 943	18	9.83 171	27	0.16 829	9.91 772	9	50
11	9.74 961	19	9.83 198	27	0.16 802	9.91 763	8	49
12	9.74 980	19	9.83 225	27	0.16 775	9.91 755	9	48
13	9.74 999	18	9.83 252	28	0.16 748	9.91 746	8	47
14	9.75 017	19	9.83 280	27	0.16 720	9.91 738	9	46
15	9.75 036	18	9.83 307	27	0.16 693	9.91 729	9	45
16	9.75 054	19	9.83 334	27	0.16 666	9.91 720	8	44
17	9.75 073	18	9.83 361	27	0.16 639	9.91 712	9	43
18	9.75 091	19	9.83 388	27	0.16 612	9.91 703	8	42
19	9.75 110	18	9.83 415	27	0.16 585	9.91 695	9	41
20	9.75 128	19	9.83 442	28	0.16 558	9.91 686	9	40
21	9.75 147	18	9.83 470	27	0.16 530	9.91 677	8	39
22	9.75 165	19	9.83 497	27	0.16 503	9.91 669	9	38
23	9.75 184	18	9.83 524	27	0.16 476	9.91 660	9	37
24	9.75 202	19	9.83 551	27	0.16 449	9.91 651	8	36
25	9.75 221	18	9.83 578	27	0.16 422	9.91 643	9	35
26	9.75 239	19	9.83 605	27	0.16 395	9.91 634	9	34
27	9.75 258	18	9.83 632	27	0.16 368	9.91 625	8	33
28	9.75 276	18	9.83 659	27	0.16 341	9.91 617	9	32
29	9.75 294	19	9.83 686	27	0.16 314	9.91 608	9	31
30	9.75 313	18	9.83 713	27	0.16 287	9.91 599	8	30
31	9.75 331	19	9.83 740	28	0.16 260	9.91 591	9	29
32	9.75 350	18	9.83 768	27	0.16 232	9.91 582	9	28
33	9.75 368	18	9.83 795	27	0.16 205	9.91 573	8	27
34	9.75 386	19	9.83 822	27	0.16 178	9.91 565	9	26
35	9.75 405	18	9.83 849	27	0.16 151	9.91 556	9	25
36	9.75 423	18	9.83 876	27	0.16 124	9.91 547	9	24
37	9.75 441	18	9.83 903	27	0.16 097	9.91 538	8	23
38	9.75 459	19	9.83 930	27	0.16 070	9.91 530	9	22
39	9.75 478	18	9.83 957	27	0.16 043	9.91 521	9	21
40	9.75 496	18	9.83 984	27	0.16 016	9.91 512	8	20
41	9.75 514	19	9.84 011	27	0.15 989	9.91 504	9	19
42	9.75 533	18	9.84 038	27	0.15 962	9.91 495	9	18
43	9.75 551	18	9.84 065	27	0.15 935	9.91 486	9	17
44	9.75 569	18	9.84 092	27	0.15 908	9.91 477	8	16
45	9.75 587	18	9.84 119	27	0.15 881	9.91 469	9	15
46	9.75 605	19	9.84 146	27	0.15 854	9.91 460	9	14
47	9.75 624	18	9.84 173	27	0.15 827	9.91 451	9	13
48	9.75 642	18	9.84 200	27	0.15 800	9.91 442	9	12
49	9.75 660	18	9.84 227	27	0.15 773	9.91 433	8	11
50	9.75 678	18	9.84 284	26	0.15 746	9.91 425	9	10
51	9.75 696	18	9.84 280	27	0.15 720	9.91 416	9	9
52	9.75 714	19	9.84 307	27	0.15 693	9.91 407	9	8
53	9.75 733	18	9.84 334	27	0.15 666	9.91 398	9	7
54	9.75 751	18	9.84 361	27	0.15 639	9.91 389	8	6
55	9.75 769	18	9.84 388	27	0.15 612	9.91 381	9	5
56	9.75 787	18	9.84 415	27	0.15 585	9.91 372	9	4
57	9.75 805	18	9.84 442	27	0.15 558	9.91 363	9	3
58	9.75 823	18	9.84 469	27	0.15 531	9.91 354	9	2
59	9.75 841	18	9.84 496	27	0.15 504	9.91 345	9	1
60	9.75 859		9.84 523		0.15 477	9.91 336		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	325°—, 145°— / 235°—, 55°—

PROP. PTS.

	28	27
1	2.8	2.7
2	5.6	5.4
3	8.4	8.1
4	11.2	10.8
5	14.0	13.5
6	16.8	16.2
7	19.6	18.9
8	22.4	21.6
9	25.3	24.3

	26
1	2.6
2	5.2
3	7.8
4	10.4
5	13.0
6	15.6
7	18.2
8	20.8
9	23.4

	19
1	1.9
2	3.8
3	5.7
4	7.6
5	9.5
6	11.4
7	13.3
8	15.2
9	17.1

	18
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2

	9	8
1	0.9	0.8
2	1.8	1.6
3	2.7	2.4
4	3.6	3.2
5	4.5	4.0
6	5.4	4.8
7	6.3	5.6
8	7.2	6.4
9	8.1	7.2

35°—, 215°— / 125°—, 305°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.75 859	18	9.84 523	27	0.15 477	9.91 336	8	60
	1	9.75 877	18	9.84 550	26	0.15 450	9.91 328	9	59
	2	9.75 895	18	9.84 576	27	0.15 424	9.91 319	9	58
	3	9.75 913	18	9.84 603	27	0.15 397	9.91 310	9	57
	4	9.75 931	18	9.84 630	27	0.15 370	9.91 301	9	56
	5	9.75 949	18	9.84 657	27	0.15 343	9.91 292	9	55
	6	9.75 967	18	9.84 684	27	0.15 316	9.91 283	9	54
	7	9.75 985	18	9.84 711	27	0.15 289	9.91 274	8	53
	8	9.76 003	18	9.84 738	26	0.15 262	9.91 266	9	52
	9	9.76 021	18	9.84 764	27	0.15 236	9.91 257	9	51
	10	9.76 039	18	9.84 791	27	0.15 209	9.91 248	9	50
	11	9.76 057	18	9.84 818	27	0.15 182	9.91 239	9	49
	12	9.76 075	18	9.84 845	27	0.15 155	9.91 230	9	48
	13	9.76 093	18	9.84 872	27	0.15 128	9.91 221	9	47
	14	9.76 111	18	9.84 899	26	0.15 101	9.91 212	9	46
	15	9.76 129	17	9.84 925	27	0.15 075	9.91 203	9	45
	16	9.76 146	18	9.84 952	27	0.15 048	9.91 194	9	44
	17	9.76 164	18	9.84 979	27	0.15 021	9.91 185	9	43
	18	9.76 182	18	9.85 006	27	0.14 994	9.91 176	9	42
	19	9.76 200	18	9.85 033	26	0.14 967	9.91 167	9	41
	20	9.76 218	18	9.85 059	27	0.14 941	9.91 158	9	40
	21	9.76 236	17	9.85 086	27	0.14 914	9.91 149	8	39
	22	9.76 253	18	9.85 113	27	0.14 887	9.91 141	9	38
	23	9.76 271	18	9.85 140	26	0.14 860	9.91 132	9	37
	24	9.76 289	18	9.85 166	27	0.14 834	9.91 123	9	36
	25	9.76 307	17	9.85 193	27	0.14 807	9.91 114	9	35
	26	9.76 324	18	9.85 220	27	0.14 780	9.91 105	9	34
	27	9.76 342	18	9.85 247	26	0.14 753	9.91 096	9	33
	28	9.76 360	18	9.85 273	27	0.14 727	9.91 087	9	32
	29	9.76 378	17	9.85 300	27	0.14 700	9.91 078	9	31
	30	9.76 395	18	9.85 327	27	0.14 673	9.91 069	9	30
	31	9.76 413	18	9.85 354	26	0.14 646	9.91 060	9	29
	32	9.76 431	17	9.85 380	27	0.14 620	9.91 051	9	28
	33	9.76 448	18	9.85 407	27	0.14 593	9.91 042	9	27
	34	9.76 466	18	9.85 434	26	0.14 566	9.91 033	10	26
	35	9.76 484	17	9.85 460	27	0.14 540	9.91 023	9	25
	36	9.76 501	18	9.85 487	27	0.14 513	9.91 014	9	24
	37	9.76 519	18	9.85 514	26	0.14 486	9.91 005	9	23
	38	9.76 537	17	9.85 540	27	0.14 460	9.90 996	9	22
	39	9.76 554	18	9.85 567	27	0.14 433	9.90 987	9	21
	40	9.76 572	18	9.85 594	26	0.14 406	9.90 978	9	20
	41	9.76 590	17	9.85 620	27	0.14 380	9.90 969	9	19
	42	9.76 607	18	9.85 647	27	0.14 353	9.90 960	9	18
	43	9.76 625	17	9.85 674	26	0.14 326	9.90 951	9	17
	44	9.76 642	18	9.85 700	27	0.14 300	9.90 942	9	16
	45	9.76 660	17	9.85 727	27	0.14 273	9.90 933	9	15
	46	9.76 677	18	9.85 754	26	0.14 246	9.90 924	9	14
	47	9.76 695	17	9.85 780	27	0.14 220	9.90 915	9	13
	48	9.76 712	18	9.85 807	27	0.14 193	9.90 906	10	12
	49	9.76 730	17	9.85 834	26	0.14 166	9.90 896	9	11
	50	9.76 747	18	9.85 860	27	0.14 140	9.90 887	9	10
	51	9.76 765	17	9.85 887	26	0.14 113	9.90 878	9	9
	52	9.76 782	18	9.85 913	27	0.14 087	9.90 869	9	8
	53	9.76 800	17	9.85 940	27	0.14 060	9.90 860	9	7
	54	9.76 817	18	9.85 967	26	0.14 033	9.90 851	9	6
	55	9.76 835	17	9.85 993	27	0.14 007	9.90 842	10	5
	56	9.76 852	18	9.86 020	26	0.13 980	9.90 832	9	4
	57	9.76 870	17	9.86 046	27	0.13 954	9.90 823	9	3
	58	9.76 887	17	9.86 073	27	0.13 927	9.90 814	9	2
	59	9.76 904	18	9.86 100	26	0.13 900	9.90 805	9	1
	60	9.76 922		9.86 126		0.13 874	9.90 796		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'

PROP. PTS.

	27	26
1	2.7	2.6
2	5.4	5.2
3	8.1	7.8
4	10.8	10.4
5	13.5	13.0
6	16.2	15.6
7	18.9	18.2
8	21.6	20.8
9	24.3	23.4

	18
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2

	17
1	1.7
2	3.4
3	5.1
4	6.8
5	8.5
6	10.2
7	11.9
8	13.6
9	15.3

	10
1	1.0
2	2.0
3	3.0
4	4.0
5	5.0
6	6.0
7	7.0
8	8.0
9	9.0

	9	8
1	0.9	0.8
2	1.8	1.6
3	2.7	2.4
4	3.6	3.2
5	4.5	4.0
6	5.4	4.8
7	6.3	5.6
8	7.2	6.4
9	8.1	7.2

324°—, 144°—

234°—, 54°—

36°__, 216°__ / 126°__, 306°__	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
	1	9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
	2	9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
	3	9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51
	10	9.77 095	17	9.86 392	26	0.13 608	9.90 704	10	50
	11	9.77 112	18	9.86 418	27	0.13 582	9.90 694	9	49
	12	9.77 130	17	9.86 445	26	0.13 555	9.90 685	9	48
	13	9.77 147	17	9.86 471	27	0.13 529	9.90 676	9	47
	14	9.77 164	17	9.86 498	26	0.13 502	9.90 667	10	46
	15	9.77 181	18	9.86 524	27	0.13 476	9.90 657	9	45
	16	9.77 199	17	9.86 551	26	0.13 449	9.90 648	9	44
	17	9.77 216	17	9.86 577	26	0.13 423	9.90 639	9	43
	18	9.77 233	17	9.86 603	27	0.13 397	9.90 630	10	42
	19	9.77 250	18	9.86 630	26	0.13 370	9.90 620	9	41
	20	9.77 268	17	9.86 656	27	0.13 344	9.90 611	9	40
	21	9.77 285	17	9.86 683	26	0.13 317	9.90 602	10	39
	22	9.77 302	17	9.86 709	27	0.13 291	9.90 592	9	38
	23	9.77 319	17	9.86 736	26	0.13 264	9.90 583	9	37
	24	9.77 336	17	9.86 762	27	0.13 238	9.90 574	9	36
	25	9.77 353	17	9.86 789	26	0.13 211	9.90 565	10	35
	26	9.77 370	17	9.86 815	27	0.13 185	9.90 555	9	34
	27	9.77 387	18	9.86 842	26	0.13 158	9.90 546	9	33
	28	9.77 405	17	9.86 868	26	0.13 132	9.90 537	10	32
	29	9.77 422	17	9.86 894	27	0.13 106	9.90 527	9	31
	30	9.77 439	17	9.86 921	26	0.13 079	9.90 518	9	30
	31	9.77 456	17	9.86 947	27	0.13 053	9.90 509	10	29
	32	9.77 473	17	9.86 974	26	0.13 026	9.90 499	9	28
	33	9.77 490	17	9.87 000	27	0.13 000	9.90 490	10	27
	34	9.77 507	17	9.87 027	26	0.12 973	9.90 480	9	26
	35	9.77 524	17	9.87 053	26	0.12 947	9.90 471	9	25
	36	9.77 541	17	9.87 079	27	0.12 921	9.90 462	10	24
	37	9.77 558	17	9.87 106	26	0.12 894	9.90 452	9	23
	38	9.77 575	17	9.87 132	26	0.12 868	9.90 443	9	22
	39	9.77 592	17	9.87 158	27	0.12 842	9.90 434	10	21
	40	9.77 609	17	9.87 185	26	0.12 815	9.90 424	9	20
	41	9.77 626	17	9.87 211	27	0.12 789	9.90 415	10	19
	42	9.77 643	17	9.87 238	26	0.12 762	9.90 405	9	18
	43	9.77 660	17	9.87 264	26	0.12 736	9.90 396	10	17
	44	9.77 677	17	9.87 290	27	0.12 710	9.90 386	9	16
	45	9.77 694	17	9.87 317	26	0.12 683	9.90 377	9	15
	46	9.77 711	17	9.87 343	26	0.12 657	9.90 368	10	14
	47	9.77 728	16	9.87 369	27	0.12 631	9.90 358	9	13
	48	9.77 744	17	9.87 396	26	0.12 604	9.90 349	10	12
	49	9.77 761	17	9.87 422	26	0.12 578	9.90 339	9	11
	50	9.77 778	17	9.87 448	27	0.12 552	9.90 330	10	10
	51	9.77 795	17	9.87 475	26	0.12 525	9.90 320	9	9
	52	9.77 812	17	9.87 501	26	0.12 499	9.90 311	10	8
	53	9.77 829	17	9.87 527	27	0.12 473	9.90 301	9	7
	54	9.77 846	16	9.87 554	26	0.12 446	9.90 292	10	6
	55	9.77 862	17	9.87 580	26	0.12 420	9.90 282	9	5
	56	9.77 879	17	9.87 606	27	0.12 394	9.90 273	10	4
	57	9.77 896	17	9.87 633	26	0.12 367	9.90 263	9	3
	58	9.77 913	17	9.87 659	26	0.12 341	9.90 254	10	2
	59	9.77 930	16	9.87 685	26	0.12 315	9.90 244	9	1
	60	9.77 946		9.87 711		0.12 289	9.90 235		0
323°__, 142°__ / 233°__, 53°__		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

PROP. PTS.

	27	26
1	2.7	2.6
2	5.4	5.2
3	8.1	7.8
4	10.8	10.4
5	13.5	13.0
6	16.2	15.6
7	18.9	18.2
8	21.6	20.8
9	24.3	23.4

	18
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2

	17
1	1.7
2	3.4
3	5.1
4	6.8
5	8.5
6	10.2
7	11.9
8	13.6
9	15.3

	16
1	1.6
2	3.2
3	4.8
4	6.4
5	8.0
6	9.6
7	11.2
8	12.8
9	14.4

	10	9
1	1.0	0.9
2	2.0	1.8
3	3.0	2.7
4	4.0	3.6
5	5.0	4.5
6	6.0	5.4
7	7.0	6.3
8	8.0	7.2
9	9.0	8.1

37°—, 217°— / 127°—, 307°—	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.77 946	17	9.87 711	27	0.12 289	9.90 235	10	60
1	9.77 963	17	9.87 738	26	0.12 262	9.90 225	9	59
2	9.77 980	17	9.87 764	26	0.12 236	9.90 216	10	58
3	9.77 997	16	9.87 790	27	0.12 210	9.90 206	9	57
4	9.78 013	17	9.87 817	26	0.12 183	9.90 197	10	56
5	9.78 030	17	9.87 843	26	0.12 157	9.90 187	9	55
6	9.78 047	16	9.87 869	26	0.12 131	9.90 178	10	54
7	9.78 063	17	9.87 895	27	0.12 105	9.90 168	9	53
8	9.78 080	17	9.87 922	26	0.12 078	9.90 159	10	52
9	9.78 097	16	9.87 948	26	0.12 052	9.90 149	10	51
10	9.78 113	17	9.87 974	26	0.12 026	9.90 139	9	50
11	9.78 130	17	9.88 000	27	0.12 000	9.90 130	10	49
12	9.78 147	16	9.88 027	26	0.11 973	9.90 120	9	48
13	9.78 163	17	9.88 053	26	0.11 947	9.90 111	10	47
14	9.78 180	17	9.88 079	26	0.11 921	9.90 101	10	46
15	9.78 197	16	9.88 105	26	0.11 895	9.90 091	9	45
16	9.78 213	17	9.88 131	27	0.11 869	9.90 082	10	44
17	9.78 230	16	9.88 158	26	0.11 842	9.90 072	9	43
18	9.78 246	17	9.88 184	26	0.11 816	9.90 063	10	42
19	9.78 263	17	9.88 210	26	0.11 790	9.90 053	10	41
20	9.78 280	16	9.88 236	26	0.11 764	9.90 043	9	40
21	9.78 296	17	9.88 262	27	0.11 738	9.90 034	10	39
22	9.78 313	16	9.88 289	26	0.11 711	9.90 024	10	38
23	9.78 329	17	9.88 315	26	0.11 685	9.90 014	9	37
24	9.78 346	16	9.88 341	26	0.11 659	9.90 005	10	36
25	9.78 362	17	9.88 367	26	0.11 633	9.89 995	10	35
26	9.78 379	16	9.88 393	27	0.11 607	9.89 985	9	34
27	9.78 395	17	9.88 420	26	0.11 580	9.89 976	10	33
28	9.78 412	16	9.88 446	26	0.11 554	9.89 966	10	32
29	9.78 428	17	9.88 472	26	0.11 528	9.89 956	9	31
30	9.78 445	16	9.88 498	26	0.11 502	9.89 947	10	30
31	9.78 461	17	9.88 524	26	0.11 476	9.89 937	10	29
32	9.78 478	16	9.88 550	27	0.11 450	9.89 927	9	28
33	9.78 494	16	9.88 577	26	0.11 423	9.89 918	10	27
34	9.78 510	17	9.88 603	26	0.11 397	9.89 908	10	26
35	9.78 527	16	9.88 629	26	0.11 371	9.89 898	10	25
36	9.78 543	17	9.88 655	26	0.11 345	9.89 888	9	24
37	9.78 560	16	9.88 681	26	0.11 319	9.89 879	10	23
38	9.78 576	16	9.88 707	26	0.11 293	9.89 869	10	22
39	9.78 592	17	9.88 733	26	0.11 267	9.89 859	10	21
40	9.78 609	16	9.88 759	27	0.11 241	9.89 849	9	20
41	9.78 625	17	9.88 786	26	0.11 214	9.89 840	10	19
42	9.78 642	16	9.88 812	26	0.11 188	9.89 830	10	18
43	9.78 658	16	9.88 838	26	0.11 162	9.89 820	10	17
44	9.78 674	17	9.88 864	26	0.11 136	9.89 810	9	16
45	9.78 691	16	9.88 890	26	0.11 110	9.89 801	10	15
46	9.78 707	16	9.88 916	26	0.11 084	9.89 791	10	14
47	9.78 723	16	9.88 942	26	0.11 058	9.89 781	10	13
48	9.78 739	17	9.88 968	26	0.11 032	9.89 771	10	12
49	9.78 756	16	9.88 994	26	0.11 006	9.89 761	9	11
50	9.78 772	16	9.89 020	26	0.10 980	9.89 752	10	10
51	9.78 788	17	9.89 046	27	0.10 954	9.89 742	10	9
52	9.78 805	16	9.89 073	26	0.10 927	9.89 732	10	8
53	9.78 821	16	9.89 099	26	0.10 901	9.89 722	10	7
54	9.78 837	16	9.89 125	26	0.10 875	9.89 712	10	6
55	9.78 853	16	9.89 151	26	0.10 849	9.89 702	9	5
56	9.78 869	17	9.89 177	26	0.10 823	9.89 693	10	4
57	9.78 886	16	9.89 203	26	0.10 797	9.89 683	10	3
58	9.78 902	16	9.89 229	26	0.10 771	9.89 673	10	2
59	9.78 918	16	9.89 255	26	0.10 745	9.89 663	10	1
60	9.78 934		9.89 281		0.10 719	9.89 653		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	322°—, 142°— / 232°—, 52°—

PROP. PTS.

	27	26	17	16	10	9
1	2.7	2.6	1.7	1.6	1.0	0.9
2	5.4	5.2	3.4	3.2	2.0	1.8
3	8.1	7.8	5.1	4.8	3.0	2.7
4	10.8	10.4	6.8	6.4	4.0	3.6
5	13.5	13.0	8.5	8.0	5.0	4.5
6	16.2	15.6	10.2	9.6	6.0	5.4
7	18.9	18.2	11.9	11.2	7.0	6.3
8	21.6	20.8	13.6	12.8	8.0	7.2
9	24.3	23.4	15.3	14.4	9.0	8.1

38°—, 218°— / 128°—, 308°—	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D		PROP. PTS.
0	9.78 934	16	9.89 281	26	0.10 719	9.89 653	10	60	
1	9.78 950	17	9.89 307	26	0.10 693	9.89 643	10	59	
2	9.78 967	16	9.89 333	26	0.10 667	9.89 633	10	58	
3	9.78 983	16	9.89 359	26	0.10 641	9.89 624	10	57	
4	9.78 999	16	9.89 385	26	0.10 615	9.89 614	10	56	
5	9.79 015	16	9.89 411	26	0.10 589	9.89 604	10	55	
6	9.79 031	16	9.89 437	26	0.10 563	9.89 594	10	54	
7	9.79 047	16	9.89 463	26	0.10 537	9.89 584	10	53	
8	9.79 063	16	9.89 489	26	0.10 511	9.89 574	10	52	
9	9.79 079	16	9.89 515	26	0.10 485	9.89 564	10	51	
10	9.79 095	16	9.89 541	26	0.10 459	9.89 554	10	50	
11	9.79 111	17	9.89 567	26	0.10 433	9.89 544	10	49	
12	9.79 128	16	9.89 593	26	0.10 407	9.89 534	10	48	
13	9.79 144	16	9.89 619	26	0.10 381	9.89 524	10	47	
14	9.79 160	16	9.89 645	26	0.10 355	9.89 514	10	46	
15	9.79 176	16	9.89 671	26	0.10 329	9.89 504	9	45	
16	9.79 192	16	9.89 697	26	0.10 303	9.89 495	10	44	
17	9.79 208	16	9.89 723	26	0.10 277	9.89 485	10	43	
18	9.79 224	16	9.89 749	26	0.10 251	9.89 475	10	42	
19	9.79 240	16	9.89 775	26	0.10 225	9.89 465	10	41	
20	9.79 256	16	9.89 801	26	0.10 199	9.89 455	10	40	
21	9.79 272	16	9.89 827	26	0.10 173	9.89 445	10	39	
22	9.79 288	16	9.89 853	26	0.10 147	9.89 435	10	38	
23	9.79 304	15	9.89 879	26	0.10 121	9.89 425	10	37	
24	9.79 319	16	9.89 905	26	0.10 095	9.89 415	10	36	
25	9.79 335	16	9.89 931	26	0.10 069	9.89 405	10	35	
26	9.79 351	16	9.89 957	26	0.10 043	9.89 395	10	34	
27	9.79 367	16	9.89 983	26	0.10 017	9.89 385	10	33	
28	9.79 383	16	9.90 009	26	0.09 991	9.89 375	11	32	
29	9.79 399	16	9.90 035	26	0.09 965	9.89 364	10	31	
30	9.79 415	16	9.90 061	25	0.09 939	9.89 354	10	30	
31	9.79 431	16	9.90 086	26	0.09 914	9.89 344	10	29	
32	9.79 447	16	9.90 112	26	0.09 888	9.89 334	10	28	
33	9.79 463	15	9.90 138	26	0.09 862	9.89 324	10	27	
34	9.79 478	16	9.90 164	26	0.09 836	9.89 314	10	26	
35	9.79 494	16	9.90 190	26	0.09 810	9.89 304	10	25	
36	9.79 510	16	9.90 216	26	0.09 784	9.89 294	10	24	
37	9.79 526	16	9.90 242	26	0.09 758	9.89 284	10	23	
38	9.79 542	16	9.90 268	26	0.09 732	9.89 274	10	22	
39	9.79 558	15	9.90 294	26	0.09 706	9.89 264	10	21	
40	9.79 573	16	9.90 320	26	0.09 680	9.89 254	10	20	
41	9.79 589	16	9.90 346	25	0.09 654	9.89 244	11	19	
42	9.79 605	16	9.90 371	26	0.09 629	9.89 233	10	18	
43	9.79 621	15	9.90 397	26	0.09 603	9.89 223	10	17	
44	9.79 636	16	9.90 423	26	0.09 577	9.89 213	10	16	
45	9.79 652	16	9.90 449	26	0.09 551	9.89 203	10	15	
46	9.79 668	16	9.90 475	26	0.09 525	9.89 193	10	14	
47	9.79 684	15	9.90 501	26	0.09 499	9.89 183	10	13	
48	9.79 699	16	9.90 527	26	0.09 473	9.89 173	11	12	
49	9.79 715	16	9.90 553	25	0.09 447	9.89 162	10	11	
50	9.79 731	15	9.90 578	26	0.09 422	9.89 152	10	10	
51	9.79 746	16	9.90 604	26	0.09 396	9.89 142	10	9	
52	9.79 762	16	9.90 630	26	0.09 370	9.89 132	10	8	
53	9.79 778	15	9.90 656	26	0.09 344	9.89 122	10	7	
54	9.79 793	16	9.90 682	26	0.09 318	9.89 112	11	6	
55	9.79 809	16	9.90 708	26	0.09 292	9.89 101	10	5	
56	9.79 825	15	9.90 734	25	0.09 266	9.89 091	10	4	
57	9.79 840	16	9.90 759	26	0.09 241	9.89 081	10	3	
58	9.79 856	16	9.90 785	26	0.09 215	9.89 071	11	2	
59	9.79 872	15	9.90 811	26	0.09 189	9.89 060	10	1	
60	9.79 887		9.90 837		0.09 163	9.89 050		0	
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′	321°—, 141°— / 231°—, 51°—

PROP. PTS.

	26	25
1	2.6	2.5
2	5.2	5.0
3	7.8	7.5
4	10.4	10.0
5	13.0	12.5
6	15.6	15.0
7	18.2	17.5
8	20.8	20.0
9	23.4	22.5

	17
1	1.7
2	3.4
3	5.1
4	6.8
5	8.5
6	10.2
7	11.9
8	13.6
9	15.3

	16	15
1	1.6	1.5
2	3.2	3.0
3	4.8	4.5
4	6.4	6.0
5	8.0	7.5
6	9.6	9.0
7	11.2	10.5
8	12.8	12.0
9	14.4	13.5

	11
1	1.1
2	2.2
3	3.3
4	4.4
5	5.5
6	6.6
7	7.7
8	8.8
9	9.9

	10	9
1	1.0	0.9
2	2.0	1.8
3	3.0	2.7
4	4.0	3.6
5	5.0	4.5
6	6.0	5.4
7	7.0	6.3
8	8.0	7.2
9	9.0	8.1

39°__, 219°__ / 129°__, 309°__	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.79 887	16	9.90 837	26	0.09 163	9.89 050	10	60
1	9.79 903	15	9.90 863	26	0.09 137	9.89 040	10	59
2	9.79 918	16	9.90 889	25	0.09 111	9.89 030	10	58
3	9.79 934	16	9.90 914	26	0.09 086	9.89 020	11	57
4	9.79 950	15	9.90 940	26	0.09 060	9.89 009	10	56
5	9.79 965	16	9.90 966	26	0.09 034	9.88 999	10	55
6	9.79 981	15	9.90 992	26	0.09 008	9.88 989	11	54
7	9.79 996	16	9.91 018	25	0.08 982	9.88 978	10	53
8	9.80 012	15	9.91 043	26	0.08 957	9.88 968	10	52
9	9.80 027	16	9.91 069	26	0.08 931	9.88 958	10	51
10	9.80 043	15	9.91 095	26	0.08 905	9.88 948	11	50
11	9.80 058	16	9.91 121	26	0.08 879	9.88 937	10	49
12	9.80 074	15	9.91 147	25	0.08 853	9.88 927	10	48
13	9.80 089	16	9.91 172	26	0.08 828	9.88 917	11	47
14	9.80 105	15	9.91 198	26	0.08 802	9.88 906	10	46
15	9.80 120	16	9.91 224	26	0.08 776	9.88 896	10	45
16	9.80 136	15	9.91 250	26	0.08 750	9.88 886	11	44
17	9.80 151	15	9.91 276	25	0.08 724	9.88 875	10	43
18	9.80 166	16	9.91 301	26	0.08 699	9.88 865	10	42
19	9.80 182	15	9.91 327	26	0.08 673	9.88 855	11	41
20	9.80 197	16	9.91 353	26	0.08 647	9.88 844	10	40
21	9.80 213	15	9.91 379	25	0.08 621	9.88 834	10	39
22	9.80 228	16	9.91 404	26	0.08 596	9.88 824	11	38
23	9.80 244	15	9.91 430	26	0.08 570	9.88 813	10	37
24	9.80 259	15	9.91 456	26	0.08 544	9.88 803	10	36
25	9.80 274	16	9.91 482	25	0.08 518	9.88 793	11	35
26	9.80 290	15	9.91 507	26	0.08 493	9.88 782	10	34
27	9.80 305	15	9.91 533	26	0.08 467	9.88 772	11	33
28	9.80 320	16	9.91 559	26	0.08 441	9.88 761	10	32
29	9.80 336	15	9.91 585	25	0.08 415	9.88 751	10	31
30	9.80 351	15	9.91 610	26	0.08 390	9.88 741	11	30
31	9.80 366	16	9.91 636	26	0.08 364	9.88 730	10	29
32	9.80 382	15	9.91 662	26	0.08 338	9.88 720	11	28
33	9.80 397	15	9.91 688	25	0.08 312	9.88 709	10	27
34	9.80 412	16	9.91 713	26	0.08 287	9.88 699	11	26
35	9.80 428	15	9.91 739	26	0.08 261	9.88 688	10	25
36	9.80 443	15	9.91 765	26	0.08 235	9.88 678	10	24
37	9.80 458	15	9.91 791	25	0.08 209	9.88 668	11	23
38	9.80 473	16	9.91 816	26	0.08 184	9.88 657	10	22
39	9.80 489	15	9.91 842	26	0.08 158	9.88 647	11	21
40	9.80 504	15	9.91 868	25	0.08 132	9.88 636	10	20
41	9.80 519	15	9.91 893	26	0.08 107	9.88 626	11	19
42	9.80 534	16	9.91 919	26	0.08 081	9.88 615	10	18
43	9.80 550	15	9.91 945	26	0.08 055	9.88 605	11	17
44	9.80 565	15	9.91 971	25	0.08 029	9.88 594	10	16
45	9.80 580	15	9.91 996	26	0.08 004	9.88 584	11	15
46	9.80 595	15	9.92 022	26	0.07 978	9.88 573	10	14
47	9.80 610	15	9.92 048	25	0.07 952	9.88 563	11	13
48	9.80 625	16	9.92 073	26	0.07 927	9.88 552	10	12
49	9.80 641	15	9.92 099	26	0.07 901	9.88 542	11	11
50	9.80 656	15	9.92 125	25	0.07 875	9.88 531	10	10
51	9.80 671	15	9.92 150	26	0.07 850	9.88 521	11	9
52	9.80 686	15	9.92 176	26	0.07 824	9.88 510	11	8
53	9.80 701	15	9.92 202	25	0.07 798	9.88 499	10	7
54	9.80 716	15	9.92 227	26	0.07 773	9.88 489	11	6
55	9.80 731	15	9.92 253	26	0.07 747	9.88 478	10	5
56	9.80 746	16	9.92 279	25	0.07 721	9.88 468	11	4
57	9.80 762	15	9.92 304	26	0.07 696	9.88 457	10	3
58	9.80 777	15	9.92 330	26	0.07 670	9.88 447	11	2
59	9.80 792	15	9.92 356	25	0.07 644	9.88 436	11	1
60	9.80 807		9.92 381		0.07 619	9.88 425		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

PROP. PTS.

	26
1	2.6
2	5.2
3	7.8
4	10.4
5	13.0
6	15.6
7	18.2
8	20.8
9	23.4

	25
1	2.5
2	5.0
3	7.5
4	10.8
5	12.5
6	15.0
7	17.5
8	20.0
9	22.5

	16
1	1.6
2	3.2
3	4.8
4	6.4
5	8.0
6	9.6
7	11.2
8	12.8
9	14.4

	15
1	1.5
2	3.0
3	4.5
4	6.0
5	7.5
6	9.0
7	10.5
8	12.0
9	13.5

	11	10
1	1.1	1.0
2	2.2	2.0
3	3.3	3.0
4	4.4	4.0
5	5.5	5.0
6	6.6	6.0
7	7.7	7.0
8	8.8	8.0
9	9.9	9.0

320°__, 140°__ / 230°__, 50°__

40°—, 220°— / 130°—, 310°—	'	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
	0	9.80 807	15	9.92 381	26	0.07 619	9.88 425	10	60
	1	9.80 822	15	9.92 407	26	0.07 593	9.88 415	11	59
	2	9.80 837	15	9.92 433	25	0.07 567	9.88 404	10	58
	3	9.80 852	15	9.92 458	26	0.07 542	9.88 394	11	57
	4	9.80 867	15	9.92 484	26	0.07 516	9.88 383	11	56
	5	9.80 882	15	9.92 510	25	0.07 490	9.88 372	10	55
	6	9.80 897	15	9.92 535	26	0.07 465	9.88 362	11	54
	7	9.80 912	15	9.92 561	26	0.07 439	9.88 351	11	53
	8	9.80 927	15	9.92 587	25	0.07 413	9.88 340	10	52
	9	9.80 942	15	9.92 612	26	0.07 388	9.88 330	11	51
	10	9.80 957	15	9.92 638	25	0.07 362	9.88 319	11	50
	11	9.80 972	15	9.92 663	26	0.07 337	9.88 308	10	49
	12	9.80 987	15	9.92 689	26	0.07 311	9.88 298	11	48
	13	9.81 002	15	9.92 715	25	0.07 285	9.88 287	11	47
	14	9.81 017	15	9.92 740	26	0.07 260	9.88 276	10	46
	15	9.81 032	15	9.92 766	26	0.07 234	9.88 266	11	45
	16	9.81 047	14	9.92 792	25	0.07 208	9.88 255	11	44
	17	9.81 061	15	9.92 817	26	0.07 183	9.88 244	10	43
	18	9.81 076	15	9.92 843	25	0.07 157	9.88 234	11	42
	19	9.81 091	15	9.92 868	26	0.07 132	9.88 223	11	41
	20	9.81 106	15	9.92 894	26	0.07 106	9.88 212	11	40
	21	9.81 121	15	9.92 920	25	0.07 080	9.88 201	10	39
	22	9.81 136	15	9.92 945	26	0.07 055	9.88 191	11	38
	23	9.81 151	15	9.92 971	25	0.07 029	9.88 180	11	37
	24	9.81 166	14	9.92 996	26	0.07 004	9.88 169	11	36
	25	9.81 180	15	9.93 022	26	0.06 978	9.88 158	10	35
	26	9.81 195	15	9.93 048	25	0.06 952	9.88 148	11	34
	27	9.81 210	15	9.93 073	26	0.06 927	9.88 137	11	33
	28	9.81 225	15	9.93 099	25	0.06 901	9.88 126	11	32
	29	9.81 240	14	9.93 124	26	0.06 876	9.88 115	10	31
	30	9.81 254	15	9.93 150	25	0.06 850	9.88 105	11	30
	31	9.81 269	15	9.93 175	26	0.06 825	9.88 094	11	29
	32	9.81 284	15	9.93 201	26	0.06 799	9.88 083	11	28
	33	9.81 299	15	9.93 227	25	0.06 773	9.88 072	11	27
	34	9.81 314	14	9.93 252	26	0.06 748	9.88 061	10	26
	35	9.81 328	15	9.93 278	25	0.06 722	9.88 051	11	25
	36	9.81 343	15	9.93 303	26	0.06 697	9.88 040	11	24
	37	9.81 358	14	9.93 329	25	0.06 671	9.88 029	11	23
	38	9.81 372	15	9.93 354	26	0.06 646	9.88 018	11	22
	39	9.81 387	15	9.93 380	26	0.06 620	9.88 007	11	21
	40	9.81 402	15	9.93 406	25	0.06 594	9.87 996	11	20
	41	9.81 417	14	9.93 431	26	0.06 569	9.87 985	10	19
	42	9.81 431	15	9.93 457	25	0.06 543	9.87 975	11	18
	43	9.81 446	15	9.93 482	26	0.06 518	9.87 964	11	17
	44	9.81 461	14	9.93 508	25	0.06 492	9.87 953	11	16
	45	9.81 475	15	9.93 533	26	0.06 467	9.87 942	11	15
	46	9.81 490	15	9.93 559	25	0.06 441	9.87 931	11	14
	47	9.81 505	14	9.93 584	26	0.06 416	9.87 920	11	13
	48	9.81 519	15	9.93 610	26	0.06 390	9.87 909	11	12
	49	9.81 534	15	9.93 636	25	0.06 364	9.87 898	11	11
	50	9.81 549	14	9.93 661	26	0.06 339	9.87 887	10	10
	51	9.81 563	15	9.93 687	25	0.06 313	9.87 877	11	9
	52	9.81 578	14	9.93 712	26	0.06 288	9.87 866	11	8
	53	9.81 592	15	9.93 738	25	0.06 262	9.87 855	11	7
	54	9.81 607	15	9.93 763	26	0.06 237	9.87 844	11	6
	55	9.81 622	14	9.93 789	25	0.06 211	9.87 833	11	5
	56	9.81 636	15	9.93 814	26	0.06 186	9.87 822	11	4
	57	9.81 651	14	9.93 840	25	0.06 160	9.87 811	11	3
	58	9.81 665	15	9.93 865	26	0.06 135	9.87 800	11	2
	59	9.81 680	14	9.93 891	25	0.06 109	9.87 789	11	1
	60	9.81 694		9.93 916		0.06 084	9.87 778		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	'
									319°—, 139°— / 229°—, 49°—

PROP. PTS.

	26	25	15	14	11	10
1	2.6	2.5	1.5	1.4	1.1	1.0
2	5.2	5.0	3.0	2.8	2.2	2.0
3	7.8	7.5	4.5	4.2	3.3	3.0
4	10.4	10.0	6.0	5.6	4.4	4.0
5	13.0	12.5	7.5	7.0	5.5	5.0
6	15.6	15.0	9.0	8.4	6.6	6.0
7	18.2	17.5	10.5	9.8	7.7	7.0
8	20.8	20.0	12.0	11.2	8.8	8.0
9	23.4	22.5	13.5	12.6	9.9	9.0

41°—, 221°— / 131°—, 311°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.81 694	15	9.93 916	26	0.06 084	9.87 778	11	60
	1	9.81 709	14	9.93 942	25	0.06 058	9.87 767	11	59
	2	9.81 723	15	9.93 967	26	0.06 033	9.87 756	11	58
	3	9.81 738	14	9.93 993	25	0.06 007	9.87 745	11	57
	4	9.81 752	15	9.94 018	26	0.05 982	9.87 734	11	56
	5	9.81 767	14	9.94 044	25	0.05 956	9.87 723	11	55
	6	9.81 781	15	9.94 069	26	0.05 931	9.87 712	11	54
	7	9.81 796	14	9.94 095	25	0.05 905	9.87 701	11	53
	8	9.81 810	15	9.94 120	26	0.05 880	9.87 690	11	52
	9	9.81 825	14	9.94 146	25	0.05 854	9.87 679	11	51
	10	9.81 839	15	9.94 171	26	0.05 829	9.87 668	11	50
	11	9.81 854	14	9.94 197	25	0.05 803	9.87 657	11	49
	12	9.81 868	14	9.94 222	26	0.05 778	9.87 646	11	48
	13	9.81 882	15	9.94 248	25	0.05 752	9.87 635	11	47
	14	9.81 897	14	9.94 273	26	0.05 727	9.87 624	11	46
	15	9.81 911	15	9.94 299	25	0.05 701	9.87 613	12	45
	16	9.81 926	14	9.94 324	26	0.05 676	9.87 601	11	44
	17	9.81 940	15	9.94 350	25	0.05 650	9.87 590	11	43
	18	9.81 955	14	9.94 375	26	0.05 625	9.87 579	11	42
	19	9.81 969	14	9.94 401	25	0.05 599	9.87 568	11	41
	20	9.81 983	15	9.94 426	26	0.05 574	9.87 557	11	40
	21	9.81 998	14	9.94 452	25	0.05 548	9.87 546	11	39
	22	9.82 012	14	9.94 477	26	0.05 523	9.87 535	11	38
	23	9.82 026	15	9.94 503	25	0.05 497	9.87 524	11	37
	24	9.82 041	14	9.94 528	26	0.05 472	9.87 513	12	36
	25	9.82 055	14	9.94 554	25	0.05 446	9.87 501	11	35
	26	9.82 069	15	9.94 579	25	0.05 421	9.87 490	11	34
	27	9.82 084	14	9.94 604	26	0.05 396	9.87 479	11	33
	28	9.82 098	14	9.94 630	25	0.05 370	9.87 468	11	32
	29	9.82 112	14	9.94 655	26	0.05 345	9.87 457	11	31
	30	9.82 126	15	9.94 681	25	0.05 319	9.87 446	12	30
	31	9.82 141	14	9.94 706	26	0.05 294	9.87 434	11	29
	32	9.82 155	14	9.94 732	25	0.05 268	9.87 423	11	28
	33	9.82 169	15	9.94 757	26	0.05 243	9.87 412	11	27
	34	9.82 184	14	9.94 783	25	0.05 217	9.87 401	11	26
	35	9.82 198	14	9.94 808	26	0.05 192	9.87 390	12	25
	36	9.82 212	14	9.94 834	25	0.05 166	9.87 378	11	24
	37	9.82 226	14	9.94 859	25	0.05 141	9.87 367	11	23
	38	9.82 240	15	9.94 884	26	0.05 116	9.87 356	11	22
	39	9.82 255	14	9.94 910	25	0.05 090	9.87 345	11	21
	40	9.82 269	14	9.94 935	26	0.05 065	9.87 324	12	20
	41	9.82 283	14	9.94 961	25	0.05 039	9.87 322	11	19
	42	9.82 297	14	9.94 986	26	0.05 014	9.87 311	11	18
	43	9.82 311	15	9.95 012	25	0.04 988	9.87 300	12	17
	44	9.82 326	14	9.95 037	25	0.04 963	9.87 288	11	16
	45	9.82 340	14	9.95 062	26	0.04 938	9.87 277	11	15
	46	9.82 354	14	9.95 088	25	0.04 912	9.87 266	11	14
	47	9.82 368	14	9.95 113	26	0.04 887	9.87 255	12	13
	48	9.82 382	14	9.95 139	25	0.04 861	9.87 243	11	12
	49	9.82 396	14	9.95 164	26	0.04 836	9.87 232	11	11
	50	9.82 410	14	9.95 190	25	0.04 810	9.87 221	12	10
	51	9.82 424	15	9.95 215	25	0.04 785	9.87 209	11	9
	52	9.82 439	14	9.95 240	26	0.04 760	9.87 198	11	8
	53	9.82 453	14	9.95 266	25	0.04 734	9.87 187	12	7
	54	9.82 467	14	9.95 291	26	0.04 709	9.87 175	11	6
	55	9.82 481	14	9.95 317	25	0.04 683	9.87 164	11	5
	56	9.82 495	14	9.95 342	26	0.04 658	9.87 153	12	4
	57	9.82 509	14	9.95 368	25	0.04 632	9.87 141	11	3
	58	9.82 523	14	9.95 393	25	0.04 607	9.87 130	11	2
	59	9.82 537	14	9.95 418	26	0.04 582	9.87 119	12	1
	60	9.82 551		9.95 444		0.04 556	9.87 107		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
318°—, 138°— / 228°—, 48°—									

PROP. PTS.

	26	25	15	14	12	11
1	2.6	2.5	1.5	1.4	1.2	1.1
2	5.2	5.0	3.0	2.8	2.4	2.2
3	7.8	7.5	4.5	4.2	3.6	3.3
4	10.4	10.0	6.0	5.6	4.8	4.4
5	13.0	12.5	7.5	7.0	6.0	5.5
6	15.6	15.0	9.0	8.4	7.2	6.6
7	18.2	17.5	10.5	9.8	8.4	7.7
8	20.8	20.0	12.0	11.2	9.6	8.8
9	23.4	22.5	13.5	12.6	10.8	9.9

42°—, 222°— / 132°—, 312°—	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.82 551	14	9.95 444	25	0.04 556	9.87 107	11	60
	1	9.82 565	14	9.95 469	26	0.04 531	9.87 096	11	59
	2	9.82 579	14	9.95 495	25	0.04 505	9.87 085	12	58
	3	9.82 593	14	9.95 520	25	0.04 480	9.87 073	11	57
	4	9.82 607	14	9.95 545	26	0.04 455	9.87 062	12	56
	5	9.82 621	14	9.95 571	25	0.04 429	9.87 050	11	55
	6	9.82 635	14	9.95 596	26	0.04 404	9.87 039	11	54
	7	9.82 649	14	9.95 622	25	0.04 378	9.87 028	12	53
	8	9.82 663	14	9.95 647	25	0.04 353	9.87 016	11	52
	9	9.82 677	14	9.95 672	26	0.04 328	9.87 005	12	51
	10	9.82 691	14	9.95 698	25	0.04 302	9.86 993	11	50
	11	9.82 705	14	9.95 723	25	0.04 277	9.86 982	12	49
	12	9.82 719	14	9.95 748	26	0.04 252	9.86 970	11	48
	13	9.82 733	14	9.95 774	25	0.04 226	9.86 959	12	47
	14	9.82 747	14	9.95 799	26	0.04 201	9.86 947	11	46
	15	9.82 761	14	9.95 825	25	0.04 175	9.86 936	12	45
	16	9.82 775	13	9.95 820	25	0.04 150	9.86 924	11	44
	17	9.82 788	14	9.95 875	26	0.04 125	9.86 913	11	43
	18	9.82 802	14	9.95 901	25	0.04 099	9.86 902	12	42
	19	9.82 816	14	9.95 926	26	0.04 074	9.86 890	11	41
	20	9.82 830	14	9.95 952	25	0.04 048	9.86 879	12	40
	21	9.82 844	14	9.95 977	25	0.04 023	9.86 867	12	39
	22	9.82 858	14	9.96 002	26	0.03 998	9.86 855	11	38
	23	9.82 872	13	9.96 028	25	0.03 972	9.86 844	12	37
	24	9.82 885	14	9.96 053	25	0.03 947	9.86 832	11	36
	25	9.82 899	14	9.96 078	26	0.03 922	9.86 821	12	35
	26	9.82 913	14	9.96 104	25	0.03 896	9.86 809	11	34
	27	9.82 927	14	9.96 129	26	0.03 871	9.86 798	12	33
	28	9.82 941	14	9.96 155	25	0.03 845	9.86 786	11	32
	29	9.82 955	13	9.96 180	25	0.03 820	9.86 775	12	31
	30	9.82 968	14	9.96 205	26	0.03 795	9.86 763	11	30
	31	9.82 982	14	9.96 231	25	0.03 769	9.86 752	12	29
	32	9.82 996	14	9.96 256	25	0.03 744	9.86 740	12	82
	33	9.83 010	13	9.96 281	26	0.03 719	9.86 728	11	27
	34	9.83 023	14	9.96 307	25	0.03 693	9.86 717	12	26
	35	9.83 037	14	9.96 332	25	0.03 668	9.86 705	11	25
	36	9.83 051	14	9.96 357	26	0.03 643	9.86 694	12	24
	37	9.83 065	13	9.96 383	25	0.03 617	9.86 682	12	23
	38	9.83 078	14	9.96 408	25	0.03 592	9.86 670	11	22
	39	9.83 092	14	9.96 433	26	0.03 567	9.86 659	12	21
	40	9.83 106	14	9.96 459	25	0.03 541	9.86 647	12	20
	41	9.83 120	13	9.96 484	26	0.03 516	9.86 635	11	19
	42	9.83 133	14	9.96 510	25	0.03 490	9.86 624	12	18
	43	9.83 147	14	9.96 535	25	0.03 465	9.86 612	12	17
	44	9.83 161	13	9.96 560	26	0.03 440	9.86 600	11	16
	45	9.83 174	14	9.96 586	25	0.03 414	9.86 589	12	15
	46	9.83 188	14	9.96 611	25	0.03 389	9.86 577	12	14
	47	9.83 202	13	9.96 636	26	0.03 364	9.86 565	11	13
	48	9.83 215	14	9.96 662	25	0.03 338	9.86 554	12	12
	49	9.83 229	13	9.96 687	25	0.03 313	9.86 542	12	11
	50	9.83 242	14	9.96 712	26	0.03 288	9.86 530	12	10
	51	9.83 256	14	9.96 738	25	0.03 262	9.86 518	11	9
	52	9.83 270	13	9.96 763	25	0.03 237	9.86 507	12	8
	53	9.83 283	14	9.96 788	26	0.03 212	9.86 495	12	7
	54	9.83 297	13	9.96 814	25	0.03 186	9.86 483	11	6
	55	9.83 310	14	9.96 839	25	0.03 161	9.86 472	12	5
	56	9.83 324	14	9.96 864	26	0.03 136	9.86 460	12	4
	57	9.83 338	13	9.96 890	25	0.03 110	9.86 448	12	3
	58	9.83 351	14	9.96 915	25	0.03 085	9.86 436	11	2
	59	9.83 365	13	9.96 940	26	0.03 060	9.86 425	12	1
	60	9.83 378		9.96 966		0.03 034	9.86 413		0
317°—, 137°— / 227°—, 47°—		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

PROP. PTS.

	26	25	14	13	12	11
1	2.6	2.5	1.4	1.3	1.2	1.1
2	5.2	5.0	2.8	2.6	2.4	2.2
3	7.8	7.5	4.2	3.9	3.6	3.3
4	10.4	10.0	5.6	5.2	4.8	4.4
5	13.0	12.5	7.0	6.5	6.0	5.5
6	15.6	15.0	8.4	7.8	7.2	6.6
7	18.2	17.5	9.8	9.1	8.4	7.7
8	20.8	20.0	11.2	10.4	9.6	8.8
9	23.4	22.5	12.6	11.7	10.8	9.9

43°__, 223°__ / 133°__, 313°__	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.83 378	14	9.96 966	25	0.03 034	9.86 413	12	60
1	9.83 392	13	9.96 991	25	0.03 009	9.86 401	12	59
2	9.83 405	14	9.97 016	26	0.02 984	9.86 389	12	58
3	9.83 419	13	9.97 042	25	0.02 958	9.86 377	11	57
4	9.83 432	14	9.97 067	25	0.02 933	9.86 366	12	56
5	9.83 446	13	9.97 092	26	0.02 908	9.86 354	12	55
6	9.83 459	14	9.97 118	25	0.02 882	9.86 342	12	54
7	9.83 473	13	9.97 143	25	0.02 857	9.86 330	12	53
8	9.83 486	14	9.97 168	25	0.02 832	9.86 318	12	52
9	9.93 500	13	9.97 193	26	0.02 807	9.86 306	11	51
10	9.83 513	14	9.97 219	25	0.02 781	9.86 295	12	50
11	9.83 527	13	9.97 244	25	0.02 756	9.86 283	12	49
12	9.83 540	14	9.97 269	26	0.02 731	9.86 271	12	48
13	9.83 554	13	9.97 295	25	0.02 705	9.86 259	12	47
14	9.83 567	14	9.95 320	25	0.02 680	9.86 247	12	46
15	9.83 581	13	9.97 345	26	0.02 655	9.86 235	12	45
16	9.83 594	14	9.97 371	25	0.02 620	9.86 223	12	44
17	9.83 608	13	9.97 396	25	0.02 601	9.86 211	11	43
18	9.83 621	13	9.97 421	25	0.02 579	9.86 200	12	42
19	9.83 634	14	9.97 447	25	0.02 553	9.86 188	12	41
20	9.83 648	13	9.97 472	25	0.02 528	9.86 176	12	40
21	9.83 661	13	9.97 497	26	0.02 503	9.86 164	12	39
22	9.83 674	14	9.97 523	25	0.02 477	9.86 152	12	38
23	9.83 688	13	9.97 518	25	0.02 452	9.86 140	12	37
24	9.83 701	14	9.97 573	25	0.02 427	9.86 128	12	36
25	9.83 715	13	9.97 598	26	0.02 402	9.86 116	12	35
26	9.83 728	13	9.97 624	25	0.02 376	9.86 104	12	34
27	9.83 741	14	9.97 649	25	0.02 351	9.86 092	12	33
28	9.83 755	13	9.97 674	26	0.02 326	9.86 080	12	32
29	9.83 768	13	9.97 700	25	0.02 300	9.86 068	12	31
30	9.83 781	14	9.97 725	25	0.02 275	9.86 056	12	30
31	9.83 795	13	9.97 750	26	0.02 250	9.86 044	12	29
32	9.83 808	13	9.97 776	25	0.02 224	9.86 032	12	28
33	9.83 821	13	9.97 801	25	0.02 190	9.86 020	12	27
34	9.83 834	14	9.97 826	25	0.02 174	9.86 008	12	26
35	9.83 848	13	9.97 851	26	0.02 149	9.85 996	12	25
36	9.83 861	13	9.97 877	25	0.02 123	9.85 984	12	24
37	9.83 874	13	9.97 902	25	0.02 098	9.85 972	12	23
38	9.83 887	14	9.97 927	26	0.02 073	9.85 960	12	22
39	9.83 901	13	9.97 953	25	0.02 047	9.85 948	12	21
40	9.83 914	13	9.97 978	25	0.02 022	9.85 936	12	20
41	9.83 927	13	9.98 003	26	0.01 997	9.85 924	12	19
42	9.83 940	14	9.98 029	25	0.01 971	9.85 912	12	18
43	9.83 954	13	9.98 054	25	0.01 946	9.85 900	12	17
44	9.83 967	13	9.98 079	25	0.01 921	9.85 888	12	16
45	9.83 980	13	9.98 104	26	0.01 896	9.85 876	12	15
46	9.83 993	13	9.98 130	25	0.01 870	9.85 864	13	14
47	9.84 006	14	9.98 155	25	0.01 845	9.85 851	12	13
48	9.84 020	13	9.98 180	26	0.01 820	9.85 839	12	12
49	9.84 033	13	9.98 206	25	0.01 794	9.85 827	12	11
50	9.84 046	13	9.98 231	25	0.01 769	9.85 815	12	10
51	9.84 059	13	9.98 256	25	0.01 744	9.85 803	12	9
52	9.84 072	13	9.98 281	26	0.01 719	9.85 791	12	8
53	9.83 085	13	9.98 307	25	0.01 693	9.85 779	13	7
54	9.84 098	14	9.98 332	25	0.01 668	9.85 766	12	6
55	9.84 112	13	9.98 357	26	0.01 643	9.85 754	12	5
56	9.84 125	13	9.98 383	25	0.01 617	9.85 742	12	4
57	9.84 138	13	9.98 408	25	0.01 592	9.85 730	12	3
58	9.84 151	13	9.98 433	25	0.01 567	9.85 718	12	2
59	9.84 164	13	9.98 458	26	0.01 542	9.85 706	13	1
60	9.84 177		9.98 484		0.01 516	9.85 693		0
	L COS / L SIN	D	L COT / L TAN	CD	L TAN / L COT	L SIN / L COS	D	316°__, 136°__ / 226°__, 46°__

PROP. PTS.

	26
1	2.6
2	5.2
3	7.8
4	10.4
5	13.0
6	15.6
7	18.2
8	20.8
9	23.4

	25
1	2.5
2	5.0
3	7.5
4	10.0
5	12.5
6	15.0
7	17.5
8	20.0
9	22.5

	14
1	1.4
2	2.8
3	4.2
4	5.6
5	7.0
6	8.4
7	9.8
8	11.2
9	12.6

	13
1	1.3
2	2.6
3	3.9
4	5.2
5	6.5
6	7.8
7	9.1
8	10.4
9	11.7

	12	11
1	1.2	1.1
2	2.4	2.2
3	3.6	3.3
4	4.8	4.4
5	6.0	5.5
6	7.2	6.6
7	8.4	7.7
8	9.6	8.8
9	10.8	9.9

44°__, 224°__ / 134°__, 314°__	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.84 177	13	9.98 484	25	0.01 516	9.85 693	12	60
1	9.84 190	13	9.98 509	25	0.01 491	9.85 681	12	59
2	9.84 203	13	9.98 534	26	0.01 466	9.85 669	12	58
3	9.84 216	13	9.98 560	25	0.01 440	9.85 657	12	57
4	9.84 229	13	9.98 585	25	0.01 415	9.85 645	13	56
5	9.84 242	13	9.98 610	25	0.01 390	9.85 632	12	55
6	9.84 255	14	9.98 635	26	0.01 365	9.85 620	12	54
7	9.84 269	13	9.98 661	25	0.01 339	9.85 608	12	53
8	9.84 282	13	9.98 686	25	0.01 314	9.85 596	13	52
9	9.84 295	13	9.98 711	26	0.01 289	9.85 583	12	51
10	9.84 308	13	9.98 737	25	0.01 263	9.85 571	12	50
11	9.84 321	13	9.98 762	25	0.01 238	9.85 559	12	49
12	9.84 334	13	9.98 787	25	0.01 213	9.85 547	13	48
13	9.84 347	13	9.98 812	26	0.01 188	9.85 534	12	47
14	9.84 360	13	9.98 838	25	0.01 162	9.85 522	12	46
15	9.84 373	12	9.98 863	25	0.01 137	9.85 510	13	45
16	9.84 385	13	9.98 888	25	0.01 112	9.85 497	12	44
17	9.84 398	13	9.98 913	26	0.01 087	9.85 485	12	43
18	9.84 411	13	9.98 939	25	0.01 061	9.85 473	13	42
19	9.84 424	13	9.98 964	25	0.01 036	9.85 460	12	41
20	9.84 437	13	9.98 989	26	0.01 011	9.85 448	12	40
21	9.84 450	13	9.99 015	25	0.00 985	9.85 436	13	39
22	9.84 463	13	9.99 040	25	0.00 960	9.85 423	12	38
23	9.8[illegible]76	13	9.99 065	25	0.00 935	9.85 411	12	37
24	9.84 489	13	9.99 090	26	0.00 910	9.85 399	13	36
25	9.84 502	13	9.99 116	25	0.00 884	9.85 386	12	35
26	9.84 515	13	9.99 141	25	0.00 859	9.85 374	13	34
27	9.84 528	12	9.99 166	25	0.00 834	9.85 361	12	33
28	9.84 540	13	9.99 191	26	0.00 809	9.85 349	12	32
29	9.84 553	13	9.99 217	25	0.00 783	9.85 337	13	31
30	9.84 566	13	9.99 242	25	0.00 758	9.85 324	12	30
31	9.84 579	13	9.99 267	26	0.00 733	9.85 312	13	29
32	9.84 592	13	9.99 293	25	0.00 707	9.85 299	12	28
33	9.84 605	13	9.99 318	25	0.00 682	9.85 287	13	27
34	9.84 618	12	9.99 343	25	0.00 657	9.85 274	12	26
35	9.84 630	13	9.99 368	26	0.00 632	9.85 262	12	25
36	9.84 643	13	9.99 394	25	0.00 606	9.85 250	13	24
37	9.84 656	13	9.99 419	25	0.00 581	9.85 237	12	23
38	9.84 669	13	9.99 444	25	0.00 556	9.85 225	13	22
39	9.84 682	12	9.99 469	26	0.00 531	9.85 212	12	21
40	9.84 694	13	9.99 495	25	0.00 505	9.85 200	13	20
41	9.84 707	13	9.99 520	25	0.00 480	9.85 187	12	19
42	9.84 720	13	9.99 545	25	0.00 455	9.85 175	13	18
43	9.84 733	12	9.99 570	26	0.00 430	9.85 162	12	17
44	9.84 745	13	9.99 596	25	0.00 404	9.85 150	13	16
45	9.84 758	13	9.99 621	25	0.00 379	9.85 137	12	15
46	9.84 771	13	9.99 646	26	0.00 354	9.85 125	13	14
47	9.84 784	12	9.99 672	25	0.00 328	9.85 112	12	13
48	9.84 796	13	9.99 697	25	0.00 303	9.85 100	13	12
49	9.84 809	13	9.99 722	25	0.00 278	9.85 087	13	11
50	9.84 822	13	9.99 747	26	0.00 253	9.85 074	12	10
51	9.84 835	12	9.99 773	25	0.00 227	9.85 062	13	9
52	9.84 847	13	9.99 798	25	0.00 202	9.85 849	12	8
53	9.84 860	13	9.99 823	25	0.00 177	9.85 037	13	7
54	9.84 873	12	9.99 848	26	0.00 152	9.85 024	12	6
55	9.84 885	13	9.99 874	25	0.00 126	9.85 012	13	5
56	9.84 898	13	9.99 899	25	0.00 101	9.84 999	13	4
57	9.84 911	12	9.99 924	25	0.00 076	9.84 986	12	3
58	9.84 923	13	9.99 949	26	0.00 051	9.84 974	13	2
59	9.84 936	13	9.99 975	25	0.00 025	9.84 961	12	1
60	9.84 949		0.00 000		0.00 000	9.84 949		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	315°__, 135°__ / 225°__, 45°__

PROP. PTS.

	26	25	14	13	12
1	2.6	2.5	1.4	1.3	1.2
2	5.2	5.0	2.8	2.6	2.4
3	7.8	7.5	4.2	3.9	3.6
4	10.4	10.0	5.6	5.2	4.8
5	13.0	12.5	7.0	6.5	6.0
6	15.6	15.0	8.4	7.8	7.2
7	18.2	17.5	9.8	9.1	8.4
8	20.8	20.0	11.2	10.4	9.6
9	23.4	22.5	12.6	11.7	10.8

Appendix C

DEAD RECKONING ALTITUDE AND AZIMUTH TABLE

WHEN LHA (E OR) W IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	0°00' A	0°00' B	0°30' A	0°30' B	1°00' A	1°00' B	1°30' A	1°30' B	2°00' A	2°00' B	'
0	-----------	0.0	205916	1.7	175814	6.6	158208	14.9	145718	26.5	30
	383730	0.0	205198	1.7	175454	6.7	157967	15.1	145538	26.7	
1	353627	0.0	204492	1.8	175097	6.8	157728	15.2	145358	26.9	29
	336018	0.0	203797	1.8	174742	7.0	157490	15.4	145179	27.1	
2	323524	0.0	203113	1.9	174391	7.1	157254	15.6	145000	27.3	28
	313833	0.0	202440	1.9	174042	7.2	157019	15.7	144823	27.6	
3	305915	0.0	201777	2.0	173696	7.3	156784	15.9	144646	27.8	27
	299221	0.0	201124	2.1	173352	7.4	156552	16.1	144470	28.0	
4	293421	0.0	200480	2.1	173012	7.5	156320	16.2	144295	28.3	26
	288306	0.0	199846	2.2	172674	7.6	156090	16.4	144120	28.5	
5	283730	0.0	199221	2.3	172339	7.8	155861	16.6	143946	28.7	25
	279591	0.1	198605	2.3	172006	7.9	155633	16.8	143773	28.9	
6	275812	0.1	197998	2.4	171676	8.0	155406	16.9	143600	29.2	24
	272336	0.1	197399	2.4	171348	8.1	155180	17.1	143428	29.4	
7	269118	0.1	196808	2.5	171023	8.2	154956	17.3	143257	29.6	23
	266121	0.1	196225	2.6	170700	8.4	154733	17.5	143086	29.9	
8	263318	0.1	195650	2.7	170379	8.5	154511	17.6	142916	30.1	22
	260685	0.1	195082	2.7	170061	8.6	154290	17.8	142747	30.4	
9	258203	0.1	194522	2.8	169745	8.7	154070	18.0	142579	30.6	21
	255855	0.2	193969	2.9	169432	8.9	153851	18.2	142411	30.8	
10	253627	0.2	193422	2.9	169121	9.0	153633	18.4	142243	31.1	20
	251508	0.2	192883	3.0	168811	9.1	153417	18.6	142077	31.3	
11	249488	0.2	192350	3.1	168505	9.3	153201	18.7	141911	31.5	19
	247558	0.2	191824	3.2	168200	9.4	152987	18.9	141745	31.8	
12	245709	0.3	191303	3.2	167897	9.5	152774	19.1	141581	32.0	18
	243936	0.3	190790	3.3	167597	9.7	152561	19.3	141417	32.3	
13	242233	0.3	190282	3.4	167298	9.8	152350	19.5	141253	32.5	17
	240594	0.3	189780	3.5	167002	9.9	152140	19.7	141090	32.8	
14	239015	0.4	189283	3.6	166708	10.1	151931	19.9	140928	33.0	16
	237491	0.4	188793	3.6	166415	10.2	151722	20.1	140766	33.3	
15	236018	0.4	188307	3.7	166125	10.3	151515	20.3	140605	33.5	15
	234594	0.4	187827	3.8	165836	10.5	151309	20.5	140445	33.7	
16	233215	0.5	187353	3.9	165550	10.6	151104	20.6	140285	34.0	14
	231879	0.5	186883	4.0	165265	10.8	150899	20.8	140125	34.2	
17	230583	0.5	186419	4.1	164982	10.9	150696	21.0	139967	34.5	13
	229324	0.6	185959	4.1	164701	11.0	150494	21.2	139809	34.7	
18	228100	0.6	185505	4.2	164422	11.2	150292	21.4	139651	35.0	12
	226910	0.6	185055	4.3	164144	11.3	150092	21.6	139494	35.3	
19	225752	0.7	184609	4.4	163868	11.5	149892	21.8	139338	35.5	11
	224624	0.7	184168	4.5	163594	11.6	149693	22.0	139182	35.8	
20	223525	0.7	183732	4.6	163322	11.8	149495	22.2	139027	36.0	10
	222452	0.8	183300	4.7	163052	11.9	149299	22.4	138872	36.3	
21	221406	0.8	182872	4.8	162783	12.1	149103	22.6	138718	36.5	9
	220384	0.9	182448	4.9	162516	12.2	148907	22.9	138564	36.8	
22	219385	0.9	182029	5.0	162250	12.4	148713	23.1	138411	37.1	8
	218409	0.9	181613	5.1	161986	12.5	148520	23.3	138258	37.3	
23	217455	1.0	181201	5.2	161724	12.7	148327	23.5	138106	37.6	7
	216521	1.0	180794	5.3	161463	12.8	148135	23.7	137955	37.9	
24	215607	1.1	180390	5.4	161204	13.0	147945	23.9	137804	38.1	6
	214711	1.1	179990	5.5	160946	13.1	147755	24.1	137653	38.4	
25	213834	1.1	179593	5.6	160690	13.3	147566	24.3	137504	38.6	5
	212974	1.2	179200	5.7	160435	13.4	147377	24.5	137354	38.9	
26	212130	1.2	178810	5.8	160182	13.6	147190	24.7	137205	39.2	4
	211303	1.3	178424	5.9	159930	13.8	147003	24.9	137057	39.4	
27	210491	1.3	178042	6.0	159680	13.9	146817	25.2	136909	39.7	3
	209695	1.4	177663	6.1	159431	14.1	146632	25.4	136761	40.0	
28	208912	1.4	177287	6.2	159184	14.2	146448	25.6	136615	40.3	2
	208143	1.5	176914	6.3	158938	14.4	146264	25.8	136468	40.5	
29	207388	1.5	176544	6.4	158693	14.6	146081	26.0	136322	40.8	1
	206646	1.6	176178	6.5	158450	14.7	145899	26.2	136177	41.1	
30	205916	1.7	175814	6.6	158208	14.9	145718	26.5	136032	41.4	0
'	A	B	A	B	A	B	A	B	A	B	'
	179°30'		179°00'		178°30'		178°00'		177°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	2°30'		3°00'		3°30'		4°00'		4°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	136032	41.4	128120	59.6	121432	81.1	115641	105.9	110536	134.1	30
	135888	41.6	128000	59.9	121329	81.5	115551	106.4	110455	134.6	
1	135744	41.9	127880	60.2	121226	81.9	115461	106.8	110375	135.1	29
	135600	42.2	127760	60.6	121124	82.2	115371	107.3	110296	135.6	
2	135457	42.5	127640	60.9	121021	82.6	115282	107.7	110216	136.1	28
	135315	42.7	127521	61.2	120919	83.0	115192	108.1	110136	136.6	
3	135173	43.0	127403	61.6	120817	83.4	115103	108.6	110057	137.1	27
	135031	43.3	127284	61.9	120715	83.8	115014	109.0	109977	137.6	
4	134890	43.6	127166	62.2	120614	84.2	114925	109.5	109898	138.1	26
	134749	43.9	127049	62.6	120513	84.6	114836	109.9	109819	138.6	
5	134609	44.2	126931	62.9	120412	85.0	114747	110.4	109740	139.1	25
	134469	44.4	126814	63.3	120311	85.4	114659	110.8	109662	139.6	
6	134330	44.7	126697	63.6	120211	85.8	114571	111.3	109583	140.1	24
	134191	45.0	126581	63.9	120110	86.2	114483	111.7	109505	140.6	
7	134052	45.3	126465	64.3	120010	86.6	114395	112.2	109426	141.1	23
	133914	45.6	126349	64.6	119910	87.0	114307	112.7	109348	141.7	
8	133777	45.9	126233	65.0	119811	87.4	114220	113.1	109270	142.2	22
	133640	46.2	126118	65.3	119711	87.8	114133	113.6	109192	142.7	
9	133503	46.5	126003	65.7	119612	88.2	114045	114.0	109115	143.2	21
	133367	46.8	125888	66.0	119513	88.6	113958	114.5	109037	143.7	
10	133231	47.1	125774	66.4	119415	89.0	113872	114.9	108960	144.2	20
	133096	47.4	125660	66.7	119316	89.4	113785	115.4	108882	144.7	
11	132961	47.6	125546	67.1	119218	89.8	113699	115.9	108805	145.2	19
	132826	47.9	125433	67.4	119120	90.2	113612	116.3	108728	145.8	
12	132692	48.2	125320	67.8	119022	90.6	113526	116.8	108651	146.3	18
	132558	48.5	125207	68.1	118925	91.0	113440	117.3	108574	146.8	
13	132425	48.8	125094	68.5	118827	91.4	113354	117.7	108498	147.3	17
	132292	49.1	124982	68.8	118730	91.8	113269	118.2	108421	147.8	
14	132159	49.4	124870	69.2	118633	92.3	113183	118.7	108345	148.4	16
	132027	49.7	124759	69.6	118537	92.7	113098	119.1	108269	148.9	
15	131896	50.0	124647	69.9	118440	93.1	113013	119.6	108193	149.4	15
	131764	50.3	124536	70.3	118344	93.5	112928	120.1	108117	149.9	
16	131633	50.7	124425	70.6	118248	93.9	112843	120.5	108041	150.5	14
	131503	51.0	124315	71.0	118152	94.3	112759	121.0	107965	151.0	
17	131373	51.3	124204	71.3	118056	94.7	112674	121.5	107890	151.5	13
	131243	51.6	124095	71.7	117961	95.2	112590	121.9	107814	152.1	
18	131114	51.9	123985	72.1	117866	95.6	112506	122.4	107739	152.6	12
	130985	52.2	123875	72.4	117771	96.0	112422	122.9	107664	153.1	
19	130856	52.5	123766	72.8	117676	96.4	112338	123.4	107589	153.6	11
	130728	52.8	123657	73.2	117581	96.9	112255	123.9	107514	154.2	
20	130600	53.1	123549	73.5	117487	97.3	112171	124.3	107439	154.7	10
	130473	53.4	123441	73.9	117393	97.7	112088	124.8	107364	155.2	
21	130346	53.7	123332	74.3	117299	98.1	112005	125.3	107290	155.8	9
	130219	54.1	123225	74.6	117205	98.5	111922	125.8	107216	156.3	
22	130093	54.4	123117	75.0	117112	99.0	111839	126.2	107141	156.9	8
	129967	54.7	123010	75.4	117018	99.4	111757	126.7	107067	157.4	
23	129841	55.0	122903	75.8	116925	99.8	111674	127.2	106993	157.9	7
	129716	55.3	122796	76.1	116832	100.3	111592	127.7	106919	158.5	
24	129591	55.7	122690	76.5	116739	100.7	111510	128.2	106846	159.0	6
	129466	56.0	122584	76.9	116647	101.1	111428	128.7	106772	159.6	
25	129342	56.3	122478	77.3	116554	101.6	111346	129.2	106698	160.1	5
	129218	56.6	122372	77.6	116462	102.0	111264	129.7	106625	160.6	
26	129095	56.9	122267	78.0	116370	102.4	111183	130.1	106552	161.2	4
	128972	57.3	122161	78.4	116278	102.9	111101	130.6	106479	161.7	
27	128849	57.6	122057	78.8	116187	103.3	111020	131.1	106406	162.3	3
	128727	57.9	121952	79.2	116096	103.7	110939	131.6	106333	162.8	
28	128605	58.2	121848	79.5	116004	104.2	110858	132.1	106260	163.4	2
	128483	58.6	121743	79.9	115913	104.6	110777	132.6	106187	163.9	
29	128362	58.9	121639	80.3	115823	105.0	110696	133.1	106115	164.5	1
	128240	59.2	121536	80.7	115732	105.5	110616	133.6	106043	165.0	
30	128120	59.6	121432	81.1	115641	105.9	110536	134.1	105970	165.6	0
'	A	B	A	B	A	B	A	B	A	B	'
	177°00'		176°30'		176°00'		175°30'		175°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	5°00' A	5°00' B	5°30' A	5°30' B	6°00' A	6°00' B	6°30' A	6°30' B	7°00' A	7°00' B	'
0	105970	165.6	101843	200.4	98076	.239	94614	.280	91411	.325	30
	105898	166.1	101777	201.0	98017	.239	94559	.281	91359	.326	
1	105826	166.7	101712	201.6	97957	.240	94503	.281	91308	.326	29
	105754	167.2	101646	202.2	97897	.241	94448	.282	91257	.327	
2	105683	167.8	101581	202.8	97837	.241	94393	.283	91205	.328	28
	105611	168.4	101516	203.5	97777	.242	94338	.284	91154	.329	
3	105539	168.9	101451	204.1	97717	.243	94283	.284	91103	.330	27
	105468	169.4	101386	204.7	97658	.243	94228	.285	91052	.330	
4	105397	170.0	101321	205.3	97598	.244	94173	.286	91001	.331	26
	105325	170.6	101256	205.9	97539	.245	94118	.287	90950	.332	
5	105254	171.1	101192	206.5	97480	.245	94063	.287	90899	.333	25
	105183	171.7	101127	207.1	97420	.246	94009	.288	90848	.333	
6	105113	172.3	101063	207.8	97361	.247	93954	.289	90798	.334	24
	105042	172.8	100998	208.4	97302	.247	93899	.289	90747	.335	
7	104971	173.4	100934	209.0	97243	.248	93845	.290	90696	.336	23
	104901	174.0	100870	209.6	97184	.249	93790	.291	90646	.337	
8	104830	174.5	100806	210.3	97126	.249	93736	.292	90595	.337	22
	104760	175.1	100742	210.9	97067	.250	93682	.292	90545	.338	
9	104690	175.7	100678	211.5	97008	.251	93628	.293	90494	.339	21
	104620	176.2	100614	212.1	96950	.251	93573	.294	90444	.340	
10	104550	176.8	100550	212.8	96891	.252	93519	.295	90394	.341	20
	104480	177.4	100487	213.4	96833	.253	93465	.295	90344	.341	
11	104411	178.0	100423	214.0	96774	.253	93411	.296	90293	.342	19
	104341	178.5	100360	214.6	96716	.254	93358	.297	90243	.343	
12	104272	179.1	100296	215.3	96658	.255	93304	.298	90193	.344	18
	104202	179.7	100233	215.9	96600	.255	93250	.298	90143	.345	
13	104133	180.3	100170	216.5	96542	.256	93196	.299	90093	.345	17
	104064	180.8	100107	217.2	96484	.257	93143	.300	90044	.346	
14	103995	181.4	100044	217.8	96426	.257	93089	.301	89994	.347	16
	103926	182.0	99981	218.4	96368	.258	93036	.301	89944	.348	
15	103857	182.6	99918	219.1	96310	.259	92982	.302	89894	.349	15
	103788	183.2	99856	219.7	96253	.260	92929	.303	89845	.349	
16	103720	183.7	99793	220.3	96195	.260	92876	.304	89795	.350	14
	103651	184.3	99731	221.0	96138	.261	92823	.304	89746	.351	
17	103583	184.9	99668	221.6	96080	.262	92769	.305	89696	.352	13
	103515	185.5	99606	222.3	96023	.262	92716	.306	89647	.353	
18	103447	186.1	99544	222.9	95966	.263	92663	.307	89597	.353	12
	103379	186.7	99481	223.5	95909	.264	92610	.307	89548	.354	
19	103311	187.2	99420	224.2	95851	.264	92558	.308	89499	.355	11
	103243	187.8	99357	224.8	95795	.265	92505	.309	89450	.356	
20	103175	188.4	99296	225.5	95737	.266	93452	.310	89401	.357	10
	103107	189.0	99234	226.1	95681	.267	92399	.310	89352	.357	
21	103040	189.6	99172	226.8	95624	.267	92347	.311	89303	.358	9
	102973	190.2	99110	227.4	95567	.268	92294	.312	89254	.359	
22	102905	190.8	99049	228.1	95510	.269	92242	.313	89205	.360	8
	102838	191.4	98988	228.7	95454	.269	92189	.313	89156	.361	
23	102771	192.0	98926	229.4	95397	.270	92137	.314	89107	.362	7
	102704	192.6	98865	230.0	95341	.271	92085	.315	89059	.362	
24	102637	193.2	98804	230.7	95285	.271	92032	.316	89010	.363	6
	102570	193.8	98743	231.3	95228	.272	91980	.316	88961	.364	
25	102504	194.4	98682	232.0	95172	.273	91928	.317	88913	.365	5
	102437	195.0	98621	232.6	95116	.274	91876	.318	88864	.366	
26	102371	195.6	98560	233.3	95060	.274	91824	.319	88816	.366	4
	102304	196.2	98499	233.9	95004	.275	91772	.319	88767	.367	
27	102238	196.8	98439	234.6	94948	.276	91720	.320	88719	.368	3
	102172	197.4	98378	235.3	94892	.276	91668	.321	88671	.369	
28	102106	198.0	98318	235.9	94836	.277	91617	.322	88623	.370	2
	102040	198.6	98257	236.6	94781	.278	91565	.323	88574	.371	
29	101974	199.2	98197	237.2	94725	.279	91514	.323	88526	.371	1
	101908	199.8	98137	237.9	94670	.279	91462	.324	88478	.372	
30	101843	200.4	98076	238.6	94614	.280	91411	.325	88430	.373	0
'	A	B	A	B	A	B	A	B	A	B	'
	174°30'		174°00'		173°30'		173°00'		172°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	7°30'		8°00'		8°30'		9°00'		9°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	88430	.373	85644	.425	83030	.480	80567	.538	78239	.600	30
	88382	.374	85599	.426	82987	.481	80527	.539	78201	.601	
1	88334	.375	85555	.426	82945	.482	80487	.540	78164	.602	29
	88286	.376	85510	.427	82903	.482	80447	.541	78126	.603	
2	88239	.376	85465	.428	82861	.483	80407	.542	78088	.604	28
	88191	.377	85420	.429	82819	.484	80368	.543	78051	.605	
3	88143	.378	85376	.430	82777	.485	80328	.544	78013	.606	27
	88096	.379	85331	.431	82735	.486	80288	.545	77976	.607	
4	88048	.380	85286	.432	82693	.487	80249	.546	77938	.608	26
	88001	.381	85242	.433	82651	.488	80209	.547	77901	.609	
5	87953	.381	85197	.434	82609	.489	80170	.548	77863	.610	25
	87906	.382	85153	.434	82567	.490	80130	.549	77826	.611	
6	87858	.383	85108	.435	82526	.491	80091	.550	77788	.612	24
	87811	.384	85064	.436	82484	.492	80051	.551	77751	.614	
7	87764	.385	85020	.437	82442	.493	80012	.552	77714	.615	23
	87716	.386	84976	.438	82400	.494	79973	.553	77677	.616	
8	87669	.387	84931	.439	82359	.495	79933	.554	77639	.617	22
	87622	.387	84887	.440	82317	.496	79894	.555	77602	.618	
9	87575	.388	84843	.441	82276	.497	79855	.556	77565	.619	21
	87528	.389	84799	.442	82234	.498	79816	.557	77528	.620	
10	87481	.390	84755	.443	82193	.499	79777	.558	77491	.621	20
	87434	.391	84711	.444	82151	.500	79737	.559	77454	.622	
11	87387	.392	84667	.444	82110	.501	79698	.560	77417	.623	19
	87341	.392	84623	.445	82069	.502	79659	.561	77380	.624	
12	87294	.393	84579	.446	82027	.503	79620	.562	77343	.625	18
	87247	.394	84535	.447	81986	.504	79581	.563	77306	.626	
13	87201	.395	84492	.448	81945	.504	79542	.564	77269	.627	17
	87154	.396	84448	.449	81904	.505	79503	.565	77232	.629	
14	87107	.397	84404	.450	81863	.506	79465	.566	77195	.630	16
	87061	.398	84361	.451	81821	.507	79426	.567	77158	.631	
15	87015	.399	84317	.452	81780	.508	79387	.568	77122	.632	15
	86968	.399	84273	.453	81739	.509	79348	.569	77085	.633	
16	86922	.400	84230	.454	81698	.510	79309	.570	77048	.634	14
	86876	.401	84186	.454	81657	.511	79271	.571	77011	.635	
17	86829	.402	84143	.455	81617	.512	79232	.573	76975	.636	13
	86783	.403	84100	.456	81576	.513	79193	.574	76938	.637	
18	86737	.404	84056	.457	81535	.514	79155	.575	76902	.638	12
	86691	.405	84013	.458	81494	.515	79116	.576	76865	.639	
19	86645	.405	83970	.459	81453	.516	79078	.577	76828	.641	11
	86599	.406	83927	.460	81413	.517	79039	.578	76792	.642	
20	86553	.407	83884	.461	81372	.518	79001	.579	76756	.643	10
	86507	.408	83840	.462	81331	.519	78962	.580	76719	.644	
21	86461	.409	83797	.463	81291	.520	78924	.581	76683	.645	9
	86415	.410	83754	.464	81250	.521	78886	.582	76646	.646	
22	86370	.411	83711	.465	81210	.522	78847	.583	76610	.647	8
	86324	.411	83668	.466	81169	.523	78809	.584	76574	.648	
23	86278	.412	83626	.467	81129	.524	78771	.585	76537	.649	7
	86233	.413	83583	.467	81088	.525	78733	.586	76501	.650	
24	86187	.414	83540	.468	81048	.526	78694	.587	76465	.652	6
	86142	.415	83497	.469	81008	.527	78656	.588	76429	.653	
25	86096	.416	83455	.470	80967	.528	78618	.589	76393	.654	5
	86051	.417	83412	.471	80927	.529	78580	.590	76357	.655	
26	86006	.418	83369	.472	80887	.530	78542	.591	76320	.656	4
	85960	.418	83327	.473	80847	.531	78504	.592	76284	.657	
27	85915	.419	83284	.474	80807	.532	78466	.593	76248	.658	3
	85870	.420	83242	.475	80767	.533	78428	.594	76212	.659	
28	85825	.421	83199	.476	80727	.534	78390	.595	76176	.660	2
	85779	.422	83157	.477	80687	.535	78352	.597	76141	.661	
29	85734	.423	83114	.478	80647	.536	78315	.598	76105	.663	1
	85689	.424	83072	.479	80607	.537	78277	.599	76069	.664	
30	85644	.425	83030	.480	30567	.538	78239	.600	76033	.665	0
'	A	B	A	B	A	B	A	B	A	B	'
	172°00'		171°30'		171°00'		170°30'		170°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	10°00' A	B	10°30' A	B	11°00' A	B	11°30' A	B	12°00' A	B	'
0	76033	.665	73937	.733	71940	.805	70034	.881	68212	.960	30
	75997	.666	73903	.735	71908	.807	70003	.882	68182	.961	
1	75961	.667	73869	.736	71875	.808	69972	.883	68153	.962	29
	75926	.668	73835	.737	71843	.809	69941	.885	68123	.964	
2	75890	.669	73801	.738	71810	.810	69910	.886	68093	.965	28
	75854	.670	73767	.739	71778	.811	69879	.887	68064	.966	
3	75819	.672	73733	.740	71746	.813	69849	.888	68034	.968	27
	75783	.673	73699	.742	71713	.814	69818	.890	68005	.969	
4	75747	.674	73665	.743	71681	.815	69787	.891	67975	.970	26
	75712	.675	73631	.744	71649	.816	69756	.892	67945	.972	
5	75676	.676	73597	.745	71616	.818	69725	.894	67916	.973	25
	75641	.677	73563	.746	71584	.819	69694	.895	67886	.974	
6	75605	.678	73530	.747	71552	.820	69664	.896	67857	.976	24
	75570	.679	73496	.749	71520	.821	69633	.897	67828	.977	
7	75534	.680	73462	.750	71488	.823	69602	.899	67798	.978	23
	75499	.682	73429	.751	71455	.824	69571	.900	67769	.980	
8	75464	.683	73395	.752	71423	.825	69541	.901	67739	.981	22
	75428	.684	73361	.753	71391	.826	69510	.903	67710	.982	
9	75393	.685	73328	.755	71359	.828	69479	.904	67681	.984	21
	75358	.686	73294	.756	71327	.829	69449	.905	67651	.985	
10	75322	.687	73260	.757	71295	.830	69418	.907	67622	.987	20
	75287	.688	73227	.758	71263	.831	69387	.908	67593	.988	
11	75252	.690	73193	.759	71231	.833	69357	.909	67563	.989	19
	75217	.691	73160	.761	71199	.834	69326	.910	67534	.991	
12	75182	.692	73127	.762	71167	.835	69296	.912	67505	.992	18
	75147	.693	73093	.763	71135	.836	69265	.913	67476	.993	
13	75112	.694	73060	.764	71104	.838	69235	.914	67447	.995	17
	75077	.695	73026	.765	71072	.839	69204	.916	67417	.996	
14	75042	.696	72993	.766	71040	.840	69174	.917	67388	.997	16
	75007	.698	72960	.768	71008	.841	69144	.918	67359	.999	
15	74972	.699	72926	.769	70976	.843	69113	.920	67330	.1000	15
	74937	.700	72893	.770	70945	.844	69083	.921	67301	.1002	
16	74902	.701	72860	.771	70913	.845	69053	.922	67272	.1003	14
	74867	.702	72827	.772	70881	.846	69022	.924	67243	.1004	
17	74832	.703	72794	.774	70850	.848	68992	.925	67214	.1006	13
	74797	.704	72760	.775	70818	.849	68962	.926	67185	.1007	
18	74763	.706	72727	.776	70786	.850	68931	.928	67156	.1008	12
	74728	.707	72694	.777	70755	.851	68901	.929	67127	.1010	
19	74693	.708	72661	.779	70723	.853	68871	.930	67098	.1011	11
	74659	.709	72628	.780	70692	.854	68841	.932	67069	.1013	
20	74624	.710	72595	.781	70660	.855	68811	.933	67040	.1014	10
	74589	.711	72562	.782	70629	.856	68781	.934	67011	.1015	
21	74555	.712	72529	.783	70597	.858	68750	.935	66982	.1017	9
	74520	.714	72496	.785	70566	.859	68720	.937	66953	.1018	
22	74486	.715	72463	.786	70534	.860	68690	.938	66925	.1020	8
	74451	.716	72430	.787	70503	.862	68660	.939	66896	.1021	
23	74417	.717	72397	.788	70471	.863	68630	.941	66867	.1022	7
	74382	.718	72365	.790	70440	.864	68600	.942	66838	.1024	
24	74348	.719	72332	.791	70409	.865	68570	.943	66810	.1025	6
	74313	.721	72299	.792	70377	.867	68540	.945	66781	.1026	
25	74279	.722	72266	.793	70346	.868	68510	.946	66752	.1028	5
	74245	.723	72234	.794	70315	.869	68480	.947	66724	.1029	
26	74210	.724	72201	.796	70284	.870	68450	.949	66695	.1031	4
	74176	.725	72168	.797	70252	.872	68421	.950	66666	.1032	
27	74142	.726	72135	.798	70221	.873	68391	.951	66638	.1033	3
	74107	.728	72103	.799	70190	.874	68361	.953	66609	.1035	
28	74073	.729	72070	.800	70159	.876	68331	.954	66580	.1036	2
	74039	.730	72038	.802	70128	.877	68301	.955	66552	.1038	
29	74005	.731	72005	.803	70097	.878	68272	.957	66523	.1039	1
	73971	.732	71973	.804	70065	.879	68242	.958	66495	.1040	
30	73937	.733	71940	.805	70034	.881	68212	.960	66466	.1042	0
'	A	B	A	B	A	B	A	B	A	B	'
	169°30'		169°00'		168°30'		168°00'		167°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	12°30'		13°00'		13°30'		14°00'		14°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	66466	1042	64791	1128	63181	1217	61632	1310	60140	1406	30
	66438	1043	64764	1129	63155	1218	61607	1311	60116	1407	
1	66409	1045	64736	1130	63129	1220	61582	1313	60091	1409	29
	66381	1046	64709	1132	63103	1221	61556	1314	60067	1411	
2	66352	1047	64682	1133	63076	1223	61531	1316	60042	1412	28
	66324	1049	64655	1135	63050	1224	61506	1317	60018	1414	
3	66296	1050	64627	1136	63024	1226	61481	1319	59994	1416	27
	66267	1052	64600	1138	62998	1227	61455	1321	59969	1417	
4	66239	1053	64573	1139	62971	1229	61430	1322	59945	1419	26
	66211	1054	64546	1141	62945	1230	61405	1324	59921	1421	
5	66182	1056	64518	1142	62919	1232	61380	1325	59896	1422	25
	66154	1057	64491	1144	62893	1234	61355	1327	59872	1424	
6	66126	1059	64464	1145	62867	1235	61330	1329	59848	1425	24
	66098	1060	64437	1147	62841	1237	61304	1330	59824	1427	
7	66069	1061	64410	1148	62815	1238	61279	1332	59800	1429	23
	66041	1063	64383	1150	62789	1240	61254	1333	59775	1430	
8	66013	1064	64356	1151	62763	1241	61229	1335	59751	1432	22
	65985	1066	64329	1152	62737	1243	61204	1336	59727	1434	
9	65957	1067	64302	1154	62711	1244	61179	1338	59703	1435	21
	65928	1069	64275	1155	62685	1246	61154	1340	59679	1437	
10	65900	1070	64248	1157	62659	1247	61129	1341	59654	1439	20
	65872	1071	64221	1158	62633	1249	61104	1343	59630	1440	
11	65844	1073	64194	1160	62607	1250	61079	1344	59606	1442	19
	65816	1074	64167	1161	62581	1252	61054	1346	59582	1444	
12	65788	1076	64140	1163	62555	1253	61029	1348	59558	1445	18
	65760	1077	64113	1164	62529	1255	61004	1349	59534	1447	
13	65732	1079	64086	1166	62503	1257	60979	1351	59510	1449	17
	65704	1080	64059	1167	62477	1258	60954	1352	59486	1450	
14	65676	1081	64032	1169	62451	1260	60929	1354	59462	1452	16
	65648	1083	64005	1170	62425	1261	60904	1356	59438	1454	
15	65620	1084	63978	1172	62400	1263	60879	1357	59414	1455	15
	65592	1086	63952	1173	62374	1264	60855	1359	59390	1457	
16	65564	1087	63925	1175	62348	1266	60830	1360	59366	1459	14
	65537	1089	63898	1176	62322	1267	60805	1362	59342	1460	
17	65509	1090	63871	1178	62296	1269	60780	1364	59318	1462	13
	65481	1091	63845	1179	62271	1270	60755	1365	59294	1464	
18	65453	1093	63818	1181	62245	1272	60730	1367	59270	1465	12
	65425	1094	63791	1182	62219	1274	60706	1368	59246	1467	
19	65398	1096	63764	1184	62194	1275	60681	1370	59222	1469	11
	65370	1097	63738	1185	62168	1277	60656	1372	59198	1470	
20	65342	1099	63711	1187	62142	1278	60631	1373	59175	1472	10
	65314	1100	63684	1188	62117	1280	60607	1375	59151	1474	
21	65287	1101	63658	1190	62091	1281	60582	1377	59127	1475	9
	65259	1103	63631	1191	62065	1283	60557	1378	59103	1477	
22	65231	1104	63605	1193	62040	1284	60533	1380	59079	1479	8
	65204	1106	63578	1194	62014	1286	60508	1381	59055	1480	
23	65176	1107	63551	1196	61989	1288	60483	1383	59032	1482	7
	65148	1109	63525	1197	61963	1289	60459	1385	59008	1484	
24	65121	1110	63498	1199	61938	1291	60434	1386	58984	1485	6
	65093	1112	63472	1200	61912	1292	60410	1388	58960	1487	
25	65066	1113	63445	1202	61887	1294	60385	1390	58937	1489	5
	65038	1114	63419	1203	61861	1295	60360	1391	58913	1490	
26	65011	1116	63392	1205	61836	1297	60336	1393	58889	1492	4
	64983	1117	63366	1206	61810	1299	60311	1394	58866	1494	
27	64956	1119	63340	1208	61785	1300	60287	1396	58842	1495	3
	64928	1120	63313	1209	61759	1301	60262	1398	58818	1497	
28	64901	1122	63287	1211	61734	1303	60238	1399	58795	1499	2
	64873	1123	63260	1212	61709	1305	60213	1401	58771	1500	
29	64846	1125	63234	1214	61683	1306	60189	1403	58748	1502	1
	64819	1126	63208	1215	61658	1308	60164	1404	58724	1504	
30	64791	1128	63181	1217	61632	1310	60140	1406	58700	1506	0
	A	B	A	B	A	B	A	B	A	B	'
	167°00'		166°30'		166°00'		165°30		165°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	15°00'		15°30'		16°00'		16°30'		17°00'		
'	A	B	A	B	B	B	A	B	A	B	'
0	58700	1506	57310	1609	55966	1716	54666	1826	53406	1940	30
	58677	1507	57287	1611	55944	1718	54644	1828	53386	1942	
1	58653	1509	57265	1612	55922	1719	54623	1830	53365	1944	29
	58630	1511	57242	1614	55900	1721	54602	1832	53344	1946	
2	58606	1512	57219	1616	55878	1723	54581	1834	53324	1948	28
	58583	1514	57196	1618	55856	1725	54559	1836	53303	1950	
3	58559	1516	57174	1619	55834	1727	54538	1837	53283	1952	27
	58536	1517	57151	1621	55812	1728	54517	1839	53262	1954	
4	58512	1519	57128	1623	55790	1730	54496	1841	53241	1956	26
	58489	1521	57106	1625	55768	1732	54474	1843	53221	1958	
5	58465	1523	57083	1627	55746	1734	54453	1845	53200	1960	25
	58442	1524	57060	1628	55725	1736	54432	1847	53180	1962	
6	58418	1526	57038	1630	55703	1738	54411	1849	53159	1964	24
	58395	1528	57015	1632	55681	1739	54390	1851	53139	1966	
7	58372	1529	56992	1634	55659	1741	54368	1853	53118	1967	23
	58348	1531	56970	1635	55637	1743	54347	1854	53098	1969	
8	58325	1533	56947	1637	55615	1745	54326	1856	53077	1971	22
	58302	1534	56925	1639	55593	1747	54305	1858	53057	1973	
9	58278	1536	56902	1641	55572	1749	54284	1860	53036	1975	21
	58255	1538	56880	1642	55550	1750	54263	1862	53016	1977	
10	58232	1540	56857	1644	55528	1752	54242	1864	52995	1979	20
	58208	1541	56835	1646	55506	1754	54220	1866	52975	1981	
11	58185	1543	56812	1648	55484	1756	54199	1868	52954	1983	19
	58162	1545	56790	1649	55463	1758	54178	1870	52934	1985	
12	58138	1546	56767	1651	55441	1760	54157	1871	52914	1987	18
	58115	1548	56745	1653	55419	1761	54136	1873	52893	1989	
13	58092	1550	56722	1655	55397	1763	54115	1875	52873	1991	17
	58069	1552	56700	1657	55376	1765	54094	1877	52852	1993	
14	58046	1553	56677	1658	55354	1767	54073	1879	52832	1995	16
	58022	1555	56655	1660	55332	1769	54052	1881	52812	1997	
15	57999	1557	56632	1662	55311	1771	54031	1883	52791	1999	15
	57976	1559	56610	1664	55289	1772	54010	1885	52771	2001	
16	57953	1560	56588	1665	55267	1774	53989	1887	52751	2003	14
	57930	1562	56565	1667	55246	1776	53968	1889	52730	2005	
17	57907	1564	56543	1669	55224	1778	53947	1890	52710	2007	13
	57884	1565	56521	1671	55202	1780	53926	1892	52690	2009	
18	57860	1567	56498	1673	55181	1782	53905	1894	52670	2010	12
	57837	1569	56476	1674	55159	1783	53884	1896	52649	2012	
19	57814	1571	56454	1676	55138	1785	53864	1898	52629	2014	11
	57791	1572	56431	1678	55116	1787	53843	1900	52609	2016	
20	57768	1574	56409	1680	55095	1789	53822	1902	52588	2018	10
	57745	1576	56387	1682	55073	1791	53801	1904	52568	2020	
21	57722	1578	56365	1683	55051	1793	53780	1906	52548	2022	9
	57699	1579	56342	1685	55030	1795	53759	1908	52528	2024	
22	57676	1581	56320	1687	55008	1796	53738	1910	52508	2026	8
	57653	1583	56298	1689	54987	1798	53718	1911	52487	2028	
23	57630	1584	56276	1691	54965	1800	53697	1913	52467	2030	7
	57607	1586	56254	1692	54944	1802	53676	1915	52447	2032	
24	57584	1588	56231	1694	54922	1804	53655	1917	52427	2034	6
	57561	1590	56209	1696	54901	1806	53634	1919	52407	2036	
25	57538	1591	56187	1698	54880	1808	53614	1921	52387	2038	5
	57516	1593	56165	1700	54858	1809	53593	1923	52366	2040	
26	57493	1595	56143	1701	54837	1811	53572	1925	52346	2042	4
	57470	1597	56121	1703	54815	1813	53551	1927	52326	2044	
27	57447	1598	56099	1705	54794	1815	53531	1929	52306	2046	3
	57424	1600	56076	1707	54773	1817	53510	1931	52286	2048	
28	57401	1602	56054	1709	54751	1819	53489	1933	52266	2050	2
	57378	1604	56032	1710	54730	1821	53468	1935	52246	2052	
29	57356	1605	56010	1712	54708	1823	53448	1936	52226	2054	1
	57333	1607	55988	1714	54687	1824	53427	1938	52206	2056	
30	57310	1609	55966	1716	54666	1826	53406	1940	52186	2058	0
'	A	B	A	B	A	B	A	B	A	B	'
	164°30'		164°00'		163°30'		163°00'		162°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	17°30'		18°00'		18°30'		19°00'		19°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	52186	.2058	51002	.2179	49852	.2304	48736	.2433	47650	.2565	30
	52166	.2060	50982	.2181	49833	.2306	48717	.2435	47633	.2568	
1	52146	.2062	50963	.2183	49815	.2309	48699	.2437	47615	.2570	29
	52126	.2064	50943	.2185	49796	.2311	48681	.2439	47597	.2572	
2	52106	.2066	50924	.2188	49777	.2313	48662	.2442	47579	.2574	28
	52086	.2068	50905	.2190	49758	.2315	48644	.2444	47561	.2576	
3	52066	.2070	50885	.2192	49739	.2317	48626	.2446	47544	.2579	27
	52046	.2072	50866	.2194	49720	.2319	48608	.2448	47526	.2581	
4	52026	.2074	50846	.2196	49702	.2321	48589	.2450	47508	.2583	26
	52006	.2076	50827	.2198	49683	.2323	48571	.2453	47490	.2585	
5	51986	.2078	50808	.2200	49664	.2325	48553	.2455	47472	.2588	25
	51966	.2080	50788	.2202	49645	.2328	48534	.2457	47455	.2590	
6	51946	.2082	50769	.2204	49626	.2330	48516	.2459	47437	.2592	24
	51926	.2084	50750	.2206	49608	.2332	48498	.2461	47419	.2594	
7	51906	.2086	50730	.2208	49589	.2334	48480	.2463	47402	.2597	23
	51886	.2088	50711	.2210	49570	.2336	48462	.2466	47384	.2599	
8	51867	.2090	50692	.2212	49551	.2338	48443	.2468	47366	.2601	22
	51847	.2092	50673	.2214	49533	.2340	48425	.2470	47348	.2603	
9	51827	.2094	50653	.2216	49514	.2343	48407	.2472	47331	.2606	21
	51807	.2096	50634	.2218	49495	.2345	48389	.2474	47313	.2608	
10	51787	.2098	50615	.2221	49477	.2347	48371	.2477	47295	.2610	20
	51767	.2100	50596	.2223	49458	.2349	48352	.2479	47278	.2613	
11	51747	.2102	50576	.2225	49439	.2351	48334	.2481	47260	.2615	19
	51728	.2104	50557	.2227	49421	.2353	48316	.2483	47242	.2617	
12	51708	.2106	50538	.2229	49402	.2355	48298	.2485	47225	.2619	18
	51688	.2108	50519	.2231	49383	.2357	48280	.2488	47207	.2622	
13	51668	.2110	50499	.2233	49365	.2360	48262	.2490	47189	.2624	17
	51649	.2112	50480	.2235	49346	.2362	48244	.2492	47172	.2626	
14	51629	.2114	50461	.2237	49327	.2364	48225	.2494	47154	.2628	16
	51609	.2116	50442	.2239	49309	.2366	48207	.2496	47137	.2631	
15	51589	.2118	50423	.2241	49290	.2368	48189	.2499	47119	.2633	15
	51570	.2120	50404	.2243	49271	.2370	48171	.2501	47101	.2635	
16	51550	.2122	50385	.2246	49253	.2372	48153	.2503	47084	.2637	14
	51530	.2124	50365	.2248	49234	.2375	48135	.2505	47066	.2640	
17	51510	.2126	50346	.2250	49216	.2377	48117	.2507	47049	.2642	13
	51491	.2128	50327	.2252	49197	.2379	48099	.2510	47031	.2644	
18	51471	.2130	50308	.2254	49179	.2381	48081	.2512	47014	.2646	12
	51451	.2132	50289	.2256	49160	.2383	48063	.2514	46996	.2649	
19	51432	.2134	50270	.2258	49141	.2385	48045	.2516	46978	.2651	11
	51412	.2136	50251	.2260	49123	.2387	48027	.2519	46961	.2653	
20	51392	.2138	50232	.2262	49104	.2390	48009	.2521	46943	.2656	10
	51373	.2141	50213	.2264	49086	.2392	47991	.2523	46926	.2658	
21	51353	.2143	50194	.2266	49067	.2394	47973	.2525	46908	.2660	9
	51334	.2145	50175	.2269	49049	.2396	47955	.2527	46891	.2662	
22	51314	.2147	50156	.2271	49030	.2398	47937	.2530	46873	.2665	8
	51294	.2149	50137	.2273	49012	.2400	47919	.2532	46856	.2667	
23	51275	.2151	50117	.2275	48993	.2403	47901	.2534	46839	.2669	7
	51255	.2153	50098	.2277	48975	.2405	47883	.2536	46821	.2672	
24	51236	.2155	50080	.2279	48957	.2407	47865	.2539	46804	.2674	6
	51216	.2157	50061	.2281	48938	.2409	47847	.2541	46786	.2676	
25	51197	.2159	50042	.2283	48920	.2411	47829	.2543	46769	.2678	5
	51177	.2161	50023	.2285	48901	.2413	47811	.2545	46751	.2681	
26	51158	.2163	50004	.2287	48883	.2416	47793	.2547	46734	.2683	4
	51138	.2165	49985	.2290	48864	.2418	47775	.2550	46716	.2685	
27	51119	.2167	49966	.2292	48846	.2420	47758	.2552	46699	.2688	3
	51099	.2169	49947	.2294	48828	.2422	47740	.2554	46682	.2690	
28	51080	.2171	49928	.2296	48809	.2424	47722	.2556	46664	.2692	2
	51060	.2173	49909	.2298	48791	.2426	47704	.2559	46647	.2694	
29	51041	.2175	49890	.2300	48772	.2429	47686	.2561	46630	.2697	1
	51021	.2177	49871	.2302	48754	.2431	47668	.2563	46612	.2699	
30	51002	.2179	49852	.2304	48736	.2433	47650	.2565	46595	.2701	0
'	A	B	A	B	A	B	A	B	A	B	'
	162°00'		161°30'		161°00'		160°30'		160°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	20°00'		20°30'		21°00'		21°30'		22°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	46595	.2701	45567	.2841	44567	.2985	43592	.3132	42642	.3283	30
	46577	.2704	45551	.2844	44551	.2988	43576	.3135	42627	.3286	
1	46560	.2706	45534	.2846	44534	.2990	43560	.3137	42611	.3288	29
	46543	.2708	45517	.2848	44518	.2992	43544	.3140	42596	.3291	
2	46525	.2711	45500	.2851	44501	.2994	43528	.3142	42580	.3294	28
	46508	.2713	45483	.2853	44485	.2997	43512	.3145	42564	.3296	
3	46491	.2715	45466	.2855	44468	.2999	43496	.3147	42549	.3299	27
	46473	.2717	45449	.2858	44452	.3002	43480	.3150	42533	.3301	
4	46456	.2720	45433	.2860	44436	.3004	43464	.3152	42518	.3304	26
	46439	.2722	45416	.2862	44419	.3007	43448	.3155	42502	.3306	
5	46422	.2724	45399	.2865	44403	.3009	43432	.3157	42486	.3309	25
	46404	.2727	45382	.2867	44386	.3012	43416	.3160	42471	.3312	
6	46387	.2729	45365	.2870	44370	.3014	43400	.3162	42455	.3314	24
	46370	.2731	45348	.2872	44354	.3016	43385	.3165	42449	.3317	
7	46353	.2734	45332	.2874	44337	.3019	43369	.3167	42424	.3319	23
	46335	.2736	45315	.2877	44321	.3021	43353	.3170	42409	.3322	
8	46318	.2738	45298	.2879	44305	.3024	43337	.3172	42393	.3324	22
	46301	.2741	45281	.2881	44288	.3026	43321	.3175	42378	.3327	
9	46284	.2743	45265	.2884	44272	.3029	43305	.3177	42362	.3329	21
	46266	.2745	45248	.2886	44256	.3031	43289	.3180	42347	.3332	
10	46249	.2748	45231	.2889	44239	.3033	43273	.3182	42331	.3335	20
	46232	.2750	45214	.2891	44223	.3036	43257	.3185	42316	.3337	
11	46215	.2752	45198	.2893	44207	.3038	43241	.3187	42300	.3340	19
	46198	.2755	45181	.2896	44190	.3041	43225	.3190	42285	.3342	
12	46181	.2757	45164	.2898	44174	.3043	43210	.3192	42269	.3345	18
	46163	.2759	45147	.2901	44158	.3046	43194	.3195	42254	.3347	
13	46146	.2761	45131	.2903	44142	.3048	43178	.3197	42238	.3350	17
	46129	.2764	45114	.2905	44125	.3051	43162	.3200	42223	.3353	
14	46112	.2766	45097	.2908	44109	.3053	43146	.3202	42207	.3355	16
	46095	.2768	45081	.2910	44093	.3056	43130	.3205	42192	.3358	
15	46078	.2771	45064	.2913	44077	.3058	43114	.3207	42176	.3360	15
	46061	.2773	45047	.2915	44060	.3060	43099	.3210	42161	.3363	
16	46043	.2775	45031	.2917	44044	.3063	43083	.3212	42145	.3366	14
	46026	.2778	45014	.2920	44028	.3065	43067	.3215	42130	.3368	
17	46009	.2780	44997	.2922	44012	.3068	43051	.3217	42115	.3371	13
	45992	.2782	44981	.2924	43995	.3070	43035	.3220	42099	.3373	
18	45975	.2785	44964	.2927	43979	.3073	43020	.3222	42084	.3376	12
	45958	.2787	44947	.2929	43963	.3075	43004	.3225	42068	.3379	
19	45941	.2789	44931	.2932	43947	.3078	42988	.3227	42053	.3381	11
	45924	.2792	44914	.2934	43931	.3080	42972	.3230	42038	.3384	
20	45907	.2794	44898	.2936	43914	.3083	42956	.3233	42022	.3386	10
	45890	.2797	44881	.2939	43898	.3085	42941	.3235	42007	.3389	
21	45873	.2799	44864	.2941	43882	.3088	42925	.3238	41991	.3391	9
	45856	.2801	44848	.2944	43866	.3090	42909	.3240	41976	.3394	
22	45839	.2804	44831	.2946	43850	.3092	42893	.3243	41961	.3387	8
	45822	.2806	44815	.2949	43834	.3095	42878	.3245	41945	.3399	
23	45805	.2808	44798	.2951	43818	.3097	42862	.3248	41930	.3402	7
	45788	.2811	44782	.2953	43801	.3100	42846	.3250	41915	.3404	
24	45771	.2813	44765	.2956	43785	.3102	42830	.3253	41899	.3407	6
	45754	.2815	44748	.2958	43769	.3105	42815	.3255	41884	.3410	
25	45737	.2818	44732	.2961	43753	.3107	42799	.3258	41869	.3412	5
	45720	.2820	44715	.2963	43737	.3110	42783	.3260	41853	.3415	
26	45703	.2822	44699	.2965	43721	.3112	42768	.3263	41838	.3418	4
	45686	.2835	44682	.2968	43705	.3115	42752	.3266	41823	.3420	
27	45669	.2827	44666	.2970	43689	.3117	42736	.3268	41808	.3423	3
	45652	.2829	44649	.2973	43673	.3120	42721	.3271	41792	.3425	
28	45635	.2832	44633	.2975	43657	.3122	42705	.3273	41777	.3428	2
	45618	.2834	44616	.2978	43641	.3125	42689	.3276	41762	.3431	
29	45601	.2836	44600	.2980	43624	.3127	42674	.3278	41746	.3433	1
	45584	.2839	44583	.2982	43608	.3130	43658	.3281	41731	.3436	
30	45567	.2841	44567	.2985	43592	.3132	42642	.3283	41716	.3438	0
'	A	B	A	B	A	B	A	B	A	B	'
	159°30'		159°00'		158°30'		158°00'		157°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	22°30'		23°00'		23°30'		24°00'		24°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	41716	.3438	40812	.3597	39930	.3760	39069	.3927	38227	.4098	30
	41701	.3441	40797	.3600	39915	.3763	39054	.3930	38213	.4101	
1	41685	.3444	40782	.3603	39901	.3766	39040	.3932	38200	.4103	29
	41670	.3446	40768	.3605	39886	.3768	39026	.3935	38186	.4106	
2	41655	.3449	40753	.3608	39872	.3771	39012	.3938	38172	.4109	28
	41640	.3452	40738	.3611	39857	.3774	38998	.3941	38158	.4112	
3	41625	.3454	40723	.3613	39843	.3777	38984	.3944	38144	.4115	27
	41609	.3457	40708	.3616	39828	.3779	38969	.3947	38130	.4118	
4	41594	.3459	40693	.3619	39814	.3782	38955	.3949	38117	.4121	26
	41579	.3462	40678	.3622	39799	.3785	38941	.3952	38103	.4124	
5	41564	.3465	40664	.3624	39785	.3788	38927	.3955	38089	.4127	25
	41549	.3467	40649	.3627	39771	.3790	38913	.3958	38075	.4129	
6	41533	.3470	40634	.3630	39756	.3793	38899	.3961	38061	.4132	24
	41518	.3473	40619	.3632	39742	.3796	38885	.3964	38048	.4135	
7	41503	.3475	40604	.3635	39727	.3799	38871	.3966	38034	.4138	23
	41488	.3478	40590	.3638	39713	.3801	38856	.3969	38020	.4141	
8	41473	.3480	40575	.3640	39698	.3804	38842	.3972	38006	.4144	22
	41458	.3483	40560	.3643	39684	.3807	38828	.3975	37992	.4147	
9	41443	.3486	40545	.3646	39669	.3810	38814	.3978	37979	.4150	21
	41427	.3488	40530	.3648	39655	.3813	38800	.3981	37965	.4153	
10	41412	.3491	40516	.3651	39641	.3815	38786	.3983	37951	.4155	20
	41397	.3494	40501	.3654	39626	.3818	38772	.3986	37937	.4158	
11	41382	.3496	40486	.3657	39612	.3821	38758	.3989	37924	.4161	19
	41367	.3499	40471	.3659	39597	.3824	38744	.3992	37910	.4164	
12	41352	.3502	40457	.3662	39583	.3826	38730	.3995	37896	.4167	18
	41337	.3504	40442	.3665	39569	.3829	38716	.3998	37882	.4170	
13	41322	.3507	40427	.3667	39554	.3832	38702	.4000	37869	.4173	17
	41307	.3509	40413	.3670	39540	.3835	38688	.4003	37855	.4176	
14	41291	.3512	40398	.3673	39525	.3838	38674	.4006	37841	.4179	16
	41276	.3515	40383	.3676	39511	.3840	38660	.4009	37828	.4182	
15	41261	.3517	40368	.3678	39497	.3843	38645	.4012	37814	.4185	15
	41246	.3520	40354	.3681	39482	.3846	38631	.4015	37800	.4187	
16	41231	.3523	40339	.3684	39468	.3849	38617	.4017	37786	.4190	14
	41216	.3525	40324	.3686	39454	.3851	38603	.4020	37773	.4193	
17	41201	.3528	40310	.3689	39439	.3854	38589	.4023	37759	.4196	13
	41186	.3531	40295	.3692	39425	.3857	38575	.4026	37745	.4199	
18	41171	.3533	40280	.3695	39411	.3860	38561	.4029	37732	.4202	12
	41156	.3536	40266	.3697	39396	.3863	38547	.4032	37718	.4205	
19	41141	.3539	40251	.3700	39382	.3865	38533	.4035	37704	.4208	11
	41126	.3541	40236	.3703	39368	.3868	38520	.4037	37691	.4211	
20	41111	.3544	40222	.3705	39353	.3871	38506	.4040	37677	.4214	10
	41096	.3547	40207	.3708	39339	.3874	38492	.4043	37663	.4217	
21	41081	.3549	40192	.3711	39325	.3876	38478	.4046	37650	.4220	9
	41066	.3552	40178	.3714	39311	.3879	38464	.4049	37636	.4222	
22	41051	.3555	40163	.3716	39296	.3882	38450	.4052	37623	.4225	8
	41036	.3557	40149	.3719	39282	.3885	38436	.4055	37609	.4228	
23	41021	.3560	40134	.3722	39268	.3888	38422	.4057	37595	.4231	7
	41006	.3563	40119	.3725	39254	.3890	38408	.4060	37582	.4234	
24	40991	.3565	40105	.3727	39239	.3893	38394	.4063	37568	.4237	6
	40976	.3568	40090	.3730	39225	.3896	38380	.4066	37554	.4240	
25	40961	.3571	40076	.3733	39211	.3899	38366	.4069	37541	.4243	5
	40946	.3573	40061	.3735	39197	.3902	38352	.4072	37527	.4246	
26	40931	.3576	40046	.3738	39182	.3904	38338	.4075	37514	.4249	4
	40916	.3579	40032	.3741	39168	.3907	38324	.4078	37500	.4252	
27	40902	.3581	40017	.3744	39154	.3910	38311	.4080	37486	.4255	3
	40887	.3584	40003	.3746	39140	.3913	38297	.4083	37473	.4258	
28	40872	.3587	39988	.3749	39125	.3916	38283	.4086	37459	.4261	2
	40857	.3589	39974	.3752	39111	.3918	38269	.4089	37446	.4264	
29	40842	.3592	39959	.3755	39097	.3921	38255	.4092	37432	.4266	1
	40827	.3595	39945	.3757	39083	.3924	38241	.4095	37419	.4269	
30	40812	.3597	39930	.3760	39069	.3927	38227	.4098	37405	.4272	0
'	A	B	A	B	A	B	A	B	A	B	'
	157°00'		156°30'		156°00'		155°30'		155°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	25°00' A	B	25°30' A	B	26°00' A	B	26°30' A	B	27°00' A	B	'
0	37405	.4272	36602	.4451	35816	.4634	35047	.4821	34295	.5012	30
	37392	.4275	36588	.4454	35803	.4637	35035	.4824	34283	.5015	
1	37378	.4278	36575	.4457	35790	.4640	35022	.4827	34270	.5018	29
	37365	.4281	36562	.4460	35777	.4643	35009	.4830	34258	.5022	
2	37351	.4284	36549	.4463	35764	.4646	34997	.4833	34246	.5025	28
	37337	.4287	36535	.4466	35751	.4649	34984	.4837	34233	.5028	
3	37324	.4290	36522	.4469	35738	.4651	34971	.4840	34221	.5031	27
	37310	.4293	36509	.4472	35725	.4656	34959	.4843	34209	.5034	
4	37297	.4296	36496	.4475	35712	.4659	34946	.4846	34196	.5038	26
	37283	.4299	36483	.4478	35699	.4662	34933	.4849	34184	.5041	
5	37270	.4302	36469	.4481	35686	.4665	34921	.4852	34172	.5044	25
	37256	.4305	36456	.4484	35674	.4668	34908	.4856	34159	.5047	
6	37243	.4308	36443	.4487	35661	.4671	34896	.4859	34147	.5051	24
	37229	.4311	36430	.4490	35648	.4674	34883	.4862	34134	.5054	
7	37216	.4314	36417	.4493	35635	.4677	34870	.4865	34122	.5057	23
	37203	.4317	36403	.4496	35622	.4680	34858	.4868	34110	.5060	
8	37189	.4320	36390	.4499	35609	.4683	34845	.4871	34097	.5064	22
	37176	.4323	36377	.4503	35596	.4686	34832	.4875	34085	.5067	
9	37162	.4326	36364	.4506	35583	.4690	34820	.4878	34073	.5070	21
	37149	.4329	36351	.4509	35571	.4693	34807	.4881	34061	.5073	
10	37135	.4332	36338	.4512	35558	.4696	34795	.4884	34048	.5076	20
	37122	.4334	36325	.4515	35545	.4699	34782	.4887	34036	.5080	
11	37108	.4337	36311	.4518	35532	.4702	34770	.4890	34024	.5083	19
	37095	.4340	36298	.4521	35519	.4705	34757	.4894	34011	.5086	
12	37081	.4343	36285	.4524	35506	.4708	34744	.4897	33999	.5089	18
	37068	.4346	36272	.4527	35493	.4711	34732	.4900	33987	.5093	
13	37055	.4349	36259	.4530	35481	.4714	34719	.4903	33974	.5096	17
	37041	.4352	36246	.4533	35468	.4718	34707	.4906	33962	.5099	
14	37028	.4355	36233	.4536	35455	.4721	34694	.4910	33950	.5102	16
	37014	.4358	36220	.4539	35442	.4724	34682	.4913	33938	.5016	
15	37001	.4361	36206	.4542	35429	.4727	34669	.4916	33925	.5109	15
	36988	.4364	36193	.4545	35417	.4730	34657	.4919	33913	.5112	
16	36974	.4367	36180	.4548	35404	.4733	34644	.4922	33901	.5115	14
	36961	.4370	36167	.4551	35391	.4736	34632	.4925	33889	.5119	
17	36948	.4373	36154	.4554	35378	.4739	34619	.4929	33876	.5122	13
	36934	.4376	36141	.4557	35365	.4742	34607	.4932	33864	.5125	
18	36921	.4379	36128	.4560	35353	.4746	34594	.4935	33852	.5128	12
	36907	.4382	36115	.4563	35340	.4749	34582	.4938	33840	.5132	
19	36894	.4385	36102	.4566	35327	.4752	34569	.4941	33827	.5135	11
	36881	.4388	36089	.4569	35314	.4755	34557	.4945	33815	.5138	
20	36867	.4391	36076	.4573	35302	.4758	34544	.4948	33803	.5142	10
	36854	.4394	36063	.4576	35289	.4761	34532	.4951	33791	.5145	
21	36841	.4397	36050	.4579	35276	.4764	34519	.4954	33779	.5148	9
	36827	.4400	36037	.4582	35263	.4769	34507	.4957	33766	.5151	
22	36814	.4403	36024	.4585	35251	.4771	34494	.4961	33754	.5155	8
	36801	.4406	36011	.4588	35238	.4774	34482	.4964	33742	.5158	
23	36787	.4409	35998	.4591	35225	.4777	34469	.4967	33730	.5161	7
	36774	.4412	35985	.4594	35212	.4780	34457	.4970	33717	.5164	
24	36761	.4415	35972	.4597	35200	.4783	34445	.4973	33705	.5168	6
	36747	.4418	35959	.4600	35187	.4786	34432	.4977	33693	.5171	
25	36734	.4421	35946	.4603	35174	.4789	34420	.4980	33681	.5174	5
	36721	.4424	35933	.4606	35161	.4793	34407	.4983	33669	.5178	
26	36708	.4427	35920	.4609	35149	.4796	34395	.4986	33657	.5181	4
	36694	.4430	35907	.4612	35136	.4799	34382	.4989	33644	.5184	
27	36681	.4433	35894	.4615	35123	.4802	34370	.4993	33632	.5187	3
	36668	.4436	35881	.4619	35111	.4805	34357	.4996	33620	.5191	
28	36655	.4439	35868	.4622	35098	.4808	34345	.4999	33608	.5194	2
	36641	.4442	35855	.4625	35085	.4811	34332	.5002	33596	.5197	
29	36628	.4445	35842	.4628	35073	.4815	34320	.5005	33584	.5200	1
	36615	.4448	35829	.4631	35060	.4818	34308	.5009	33572	.5204	
30	36602	.4451	35816	.4634	35047	.4821	34295	.5012	33559	.5207	0
'	A	B	A	B	A	B	A	B	A	B	'
	154°30'		154°00'		153°30'		153°00'		152°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

'	27°30' A	B	28°00' A	B	28°30' A	B	29°00' A	B	29°30' A	B	'
0	33559	.5207	32839	.5406	32134	.5610	31443	.5818	30766	.6030	30
	33547	.5210	32827	.5410	32122	.5614	31431	.5822	30755	.6034	
1	33535	.5214	32815	.5413	32110	.5617	31420	.5825	30744	.6038	29
	33523	.5217	32803	.5417	32099	.5620	31409	.5829	30733	.6041	
2	33511	.5220	32792	.5420	32087	.5624	31397	.5832	30721	.6045	28
	33499	.5224	32780	.5423	32076	.5627	31386	.5836	30710	.6048	
3	33487	.5227	32768	.5426	32064	.5631	31375	.5839	30699	.6052	27
	33475	.5230	32756	.5430	32052	.5634	31363	.5843	30688	.6055	
4	33462	.5233	32744	.5433	32041	.5638	31352	.5846	30677	.6059	26
	33450	.5237	32732	.5437	32029	.5641	31340	.5850	30666	.6062	
5	33438	.5240	32720	.5440	32018	.5645	31329	.5853	30655	.6066	25
	33426	.5243	32709	.5443	32006	.5648	31318	.5857	30643	.6070	
6	33414	.5247	32697	.5447	31994	.5651	31306	.5860	30632	.6073	24
	33402	.5250	32685	.5450	31983	.5655	31295	.5864	30621	.6077	
7	33390	.5253	32673	.5454	31971	.5658	31284	.5867	30610	.6080	23
	33378	.5257	32661	.5457	31960	.5662	31272	.5871	30599	.6084	
8	33366	.5260	32649	.5460	31948	.5665	31261	.5874	30588	.6088	22
	33354	.5263	32638	.5464	31936	.5669	31250	.5878	30577	.6091	
9	33342	.5266	32625	.5467	31925	.5672	31238	.5881	30566	.6095	21
	33330	.5270	32614	.5470	31913	.5675	31227	.5885	30555	.6098	
10	33318	.5273	32602	.5474	31902	.5679	31216	.5888	30544	.6102	20
	33306	.5277	32590	.5477	31890	.5682	31204	.5892	30532	.6106	
11	33293	.5280	32579	.5481	31879	.5686	31193	.5895	30521	.6109	19
	33281	.5283	32567	.5484	31867	.5689	31182	.5899	30510	.6113	
12	33269	.5287	32555	.5487	31856	.5693	31170	.5902	30499	.6116	18
	33257	.5290	32543	.5491	31844	.5696	31159	.5906	30488	.6120	
13	33245	.5293	32532	.5494	31833	.5700	31148	.5909	30477	.6124	17
	33233	.5296	32520	.5498	31821	.5703	31137	.5913	30466	.6127	
14	33221	.5300	32508	.5501	31809	.5707	31125	.5917	30455	.6131	16
	33209	.5303	32496	.5504	31798	.5710	31114	.5920	30444	.6134	
15	33197	.5306	32484	.5508	31786	.5714	31103	.5924	30433	.6138	15
	33185	.5310	32473	.5511	31775	.5717	31091	.5927	30422	.6142	
16	33173	.5313	32461	.5515	31763	.5720	31080	.5931	30411	.6145	14
	33161	.5316	32449	.5518	31752	.5724	31069	.5934	30400	.6149	
17	33149	.5320	32438	.5521	31740	.5727	31058	.5938	30389	.6153	13
	33137	.5323	32426	.5525	31729	.5731	31046	.5941	30378	.6156	
18	33125	.5326	32414	.5528	31717	.5734	31035	.5945	30367	.6160	12
	33113	.5330	32402	.5532	31706	.5738	31024	.5948	30356	.6163	
19	33101	.5333	32391	.5535	31694	.5741	31013	.5952	30345	.6167	11
	33089	.5336	32379	.5538	31683	.5745	31001	.5955	30334	.6171	
20	33077	.5340	32367	.5542	31672	.5748	30990	.5959	30322	.6174	10
	33065	.5343	32355	.5545	31660	.5752	30979	.5963	30311	.6178	
21	33054	.5346	32344	.5549	31648	.5755	30968	.5966	30300	.6181	9
	33042	.5350	32332	.5552	31637	.5759	30956	.5970	30289	.6185	
22	33030	.5353	32320	.5555	31626	.5762	30945	.5973	30278	.6189	8
	33018	.5356	32309	.5559	31614	.5766	30934	.5977	30267	.6192	
23	33006	.5360	32297	.5562	31603	.5769	30923	.5980	30256	.6196	7
	32994	.5363	32285	.5566	31591	.5773	30912	.5984	30245	.6200	
24	32982	.5366	32274	.5569	31580	.5776	30900	.5988	30235	.6203	6
	32970	.5370	32262	.5572	31569	.5780	30889	.5991	30224	.6207	
25	32958	.5373	32250	.5576	31557	.5783	30878	.5995	30213	.6210	5
	32946	.5376	32239	.5579	31546	.5787	30867	.5998	30202	.6214	
26	32934	.5380	32227	.5583	31534	.5790	30856	.6002	30191	.6218	4
	32922	.5383	32215	.5586	31523	.5794	30844	.6005	30180	.6221	
27	32910	.5386	32204	.5590	31511	.5797	30833	.6009	30169	.6225	3
	32898	.5390	32192	.5593	31500	.5801	30822	.6012	30158	.6229	
28	32887	.5393	32180	.5596	31488	.5804	30811	.6016	30147	.6232	2
	32875	.5396	32169	.5600	31477	.5808	30800	.6020	30136	.6236	
29	32863	.5400	32157	.5603	31466	.5811	30788	.6023	30125	.6240	1
	32851	.5403	32145	.5607	31454	.5815	30777	.6027	30114	.6243	
30	32839	.5406	32134	.5610	31443	.5818	30766	.6030	30103	.6247	0
'	A	B	A	B	A	B	A	B	A	B	'
	152°00'		151°30'		151°00'		150°30'		150°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	30°00' A	30°00' B	30°30' A	30°30' B	31°00' A	31°00' B	31°30' A	31°30' B	32°00' A	32°00' B	'
0	30103	.6247	29453	.6468	28816	.6693	28191	.6923	27579	.7158	30
	30092	.6251	29442	.6472	28806	.6697	28181	.6927	27569	.7162	
1	30081	.6254	29432	.6475	28795	.6701	28171	.6931	27559	.7166	29
	30070	.6258	29421	.6479	28785	.6705	28161	.6935	27549	.7170	
2	30059	.6262	29410	.6483	28774	.6709	28150	.6939	27539	.7174	28
	30048	.6265	29399	.6487	28763	.6712	28140	.6943	27528	.7178	
3	30037	.6269	29389	.6490	28753	.6716	28130	.6947	27518	.7182	27
	30026	.6273	29378	.6494	28743	.6720	28119	.6951	27508	.7186	
4	30016	.6276	29367	.6498	28732	.6724	28109	.6954	27498	.7190	26
	30005	.6280	29357	.6501	28722	.6728	28099	.6958	27488	.7193	
5	29994	.6284	29346	.6505	28711	.6731	28089	.6962	27478	.7197	25
	29983	.6287	29335	.6509	28701	.6735	28078	.6966	27468	.7201	
6	29972	.6291	29325	.6513	28690	.6739	28068	.6970	27458	.7205	24
	29961	.6294	29314	.6516	28680	.6743	28058	.6974	27448	.7209	
7	29950	.6298	29303	.6520	28669	.6747	28047	.6978	27438	.7213	23
	29939	.6302	29293	.6524	28659	.6750	28037	.6982	27428	.7217	
8	29928	.6305	29282	.6528	28648	.6754	28027	.6985	27418	.7221	22
	29917	.6309	29271	.6531	28638	.6758	28017	.6989	27408	.7225	
9	29907	.6313	29261	.6535	28627	.6762	28006	.6993	27398	.7229	21
	29896	.6316	29250	.6539	28617	.6766	27996	.6997	27387	.7233	
10	29885	.6320	29239	.6543	28606	.6770	27986	.7001	27377	.7237	20
	29874	.6324	29229	.6546	28596	.6773	27976	.7005	27367	.7241	
11	29863	.6328	29218	.6550	28586	.6777	27965	.7009	27357	.7245	19
	29852	.6331	29207	.6554	28575	.6781	27955	.7013	27347	.7249	
12	29841	.6335	29197	.6558	28565	.6785	27945	.7017	27337	.7253	18
	29831	.6339	29186	.6561	28554	.6789	27935	.7021	27327	.7257	
13	29820	.6342	29175	.6565	28544	.6793	27925	.7024	27317	.7261	17
	29809	.6346	29165	.6569	28533	.6796	27914	.7028	27307	.7265	
14	29798	.6350	29154	.6573	28523	.6800	27904	.7032	27297	.7269	16
	29787	.6353	29144	.6576	28513	.6804	27894	.7036	27287	.7273	
15	29776	.6357	29133	.6580	28502	.6808	27884	.7040	27277	.7277	15
	29766	.6361	29122	.6584	28492	.6812	27874	.7044	27267	.7281	
16	29755	.6364	29112	.6588	28481	.6815	27863	.7048	27257	.7285	14
	29744	.6368	29101	.6591	28471	.6819	27853	.7052	27247	.7289	
17	29733	.6372	29091	.6595	28461	.6823	27843	.7056	27237	.7293	13
	29722	.6375	29080	.6599	28450	.6827	27833	.7060	27227	.7297	
18	29711	.6379	29069	.6603	28440	.6831	27823	.7064	27217	.7301	12
	29701	.6383	29059	.6606	28429	.6835	27812	.7067	27207	.7305	
19	29690	.6386	29048	.6610	28419	.6839	27802	.7071	27197	.7309	11
	29679	.6390	29038	.6614	28409	.6842	27792	.7075	27187	.7313	
20	29668	.6394	29027	.6618	28398	.6846	27782	.7079	27177	.7317	10
	29657	.6398	29016	.6622	28388	.6850	27772	.7083	27167	.7321	
21	29647	.6401	29006	.6625	28378	.6854	27761	.7087	27157	.7325	9
	29636	.6405	28995	.6629	28367	.6858	27751	.7091	27147	.7320	
22	29625	.6409	28985	.6633	28357	.6862	27741	.7095	27137	.7333	8
	29614	.6412	28974	.6637	28346	.6865	27731	.7099	27127	.7337	
23	29604	.6416	28964	.6640	28336	.6869	27721	.7103	27117	.7341	7
	2[illegible]93	.6420	28953	.6644	28326	.6873	27711	.7107	27107	.7345	
24	29582	.6423	28942	.6648	28315	.6877	27701	.7111	27098	.7349	6
	29571	.6427	28932	.6652	28305	.6881	27690	.7115	27088	.7353	
25	29560	.6431	28921	.6655	28295	.6885	27680	.7118	27078	.7357	5
	29550	.6435	28911	.6659	28284	.6889	27670	.7122	27068	.7361	
26	29539	.6438	28900	.6663	28274	.6893	27660	.7126	27058	.7365	4
	29528	.6442	28890	.6667	28264	.6896	27650	.7130	27048	.7369	
27	29517	.6446	28879	.6671	28253	.6900	27640	.7134	27038	.7373	3
	29507	.6449	28869	.6674	28243	.6904	27630	.7138	27028	.7377	
28	29496	.6453	28858	.6678	28233	.6908	27619	.7142	27018	.7381	2
	29485	.6457	28848	.6682	28222	.6912	27609	.7146	27008	.7385	
29	29475	.6461	28837	.6686	28212	.6916	27599	.7150	26998	.7389	1
	29464	.6464	28827	.6690	28202	.6920	27589	.7154	26988	.7393	
30	29453	.6468	28816	.6693	28191	.6923	27579	.7158	26978	.7397	0
'	A	B	A	B	A	B	A	B	A	B	'
	149°30'		149°00'		148°30'		148°00'		147°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	32°30'		33°00'		33°30'		34°00'		34°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	26978	.7397	26389	.7641	25811	.7889	25244	.8143	24687	.8401	30
	26968	.7401	26379	.7645	25801	.7893	25235	.8147	24678	.8405	
1	26958	.7405	26370	.7649	25792	.7898	25225	.8151	24669	.8409	29
	26949	.7409	26360	.7653	25782	.7902	25216	.8155	24660	.8414	
2	26939	.7413	26350	.7657	25773	.7906	25206	.8160	24650	.8418	28
	26929	.7417	26340	.7661	25763	.7910	25197	.8164	24641	.8422	
3	26919	.7421	26331	.7665	25754	.7914	25188	.8168	24632	.8427	27
	26909	.7425	26321	.7670	25744	.7919	25178	.8172	24623	.8431	
4	26899	.7429	26311	.7674	25735	.7923	25169	.8177	24614	.8435	26
	26889	.7433	26302	.7678	25725	.7927	25160	.8181	24605	.8440	
5	26879	.7437	26292	.7682	25716	.7931	25150	.8185	24595	.8444	25
	26869	.7441	26282	.7686	25706	.7935	25141	.8189	24586	.8448	
6	26860	.7445	26273	.7690	25697	.7940	25132	.8194	24577	.8453	24
	26850	.7449	26263	.7694	25687	.7944	25122	.8198	24568	.8457	
7	26840	.7453	26253	.7698	25678	.7948	25113	.8202	24559	.8461	23
	26830	.7458	26244	.7702	25668	.7952	25104	.8207	24550	.8466	
8	26820	.7462	26234	.7707	25659	.7956	25094	.8211	24540	.8470	22
	26810	.7466	26224	.7711	25649	.7961	25085	.8215	24531	.8475	
9	26800	.7470	26214	.7715	25640	.7965	25076	.8219	24522	.8479	21
	26790	.7474	26205	.7719	25630	.7969	25066	.8224	24513	.8483	
10	26781	.7478	26195	.7723	25621	.7973	25057	.8228	24504	.8488	20
	26771	.7482	26185	.7727	25611	.7977	25048	.8232	24495	.8492	
11	26761	.7486	26176	.7731	25602	.7982	25038	.8237	24486	.8496	19
	26751	.7490	26166	.7736	25592	.7986	25029	.8241	24477	.8501	
12	26741	.7494	26157	.7740	25583	.7990	25020	.8245	24467	.8505	18
	26731	.7498	26147	.7744	25573	.7994	25011	.8249	24458	.8510	
13	26722	.7502	26137	.7748	25564	.7998	25001	.8254	24449	.8514	17
	26712	.7506	26128	.7752	25554	.8003	24992	.8258	24440	.8518	
14	26702	.7510	26118	.7756	25545	.8007	24983	.8262	24431	.8523	16
	26692	.7514	26108	.7760	25536	.8011	24973	.8267	24422	.8527	
15	26682	.7518	26099	.7764	25526	.8015	24964	.8271	24413	.8531	15
	26672	.7522	26089	.7769	25517	.8020	24955	.8275	24404	.8536	
16	26663	.7526	26079	.7773	25507	.8024	24946	.8280	24395	.8540	14
	26653	.7531	26070	.7777	25498	.8028	24936	.8284	24385	.8545	
17	26643	.7535	26060	.7781	25488	.8032	24927	.8288	24376	.8549	13
	26633	.7539	26051	.7785	25479	.8037	24918	.8292	24367	.8553	
18	26623	.7543	26041	.7789	25469	.8041	24909	.8297	24358	.8558	12
	26614	.7547	26031	.7793	25460	.8045	24899	.8301	24349	.8562	
19	26604	.7551	26022	.7798	25451	.8049	24890	.8305	24340	.8567	11
	26594	.7555	26012	.7802	25441	.8053	24881	.8310	24331	.8571	
20	26584	.7559	26002	.7806	25432	.8058	24872	.8314	24322	.8575	10
	26574	.7563	25993	.7810	25422	.8062	24862	.8318	24313	.8580	
21	26565	.7567	25983	.7814	25413	.8066	24853	.8323	24304	.8584	9
	26555	.7571	25974	.7818	25403	.8070	24844	.8327	24295	.8589	
22	26545	.7575	25964	.7823	25394	.8075	24835	.8331	24286	.8593	8
	26535	.7579	25954	.7827	25385	.8079	24825	.8336	24276	.8597	
23	26526	.7584	25945	.7831	25375	.8083	24816	.8340	24267	.8602	7
	26516	.7588	25935	.7835	25366	.8087	24807	.8344	24258	.8606	
24	26506	.7592	25926	.7839	25356	.8091	24798	.8349	24249	.8611	6
	26496	.7596	25916	.7843	25347	.8096	24788	.8353	24240	.8615	
25	26486	.7600	25907	.7848	25338	.8100	24779	.8357	24231	.8619	5
	26477	.7604	25897	.7852	25328	.8104	24770	.8362	24222	.8624	
26	26467	.7608	25887	.7856	25319	.8108	24761	.8366	24213	.8628	4
	26457	.7612	25878	.7860	25309	.8113	24752	.8370	24204	.8633	
27	26447	.7616	25868	.7864	25300	.8117	24742	.8375	24195	.8637	3
	26438	.7620	25859	.7868	25291	.8121	24733	.8379	24186	.8641	
28	26428	.7625	25849	.7873	25281	.8125	24724	.8383	24177	.8646	2
	26418	.7629	25840	.7877	25272	.8130	24715	.8388	24168	.8650	
29	26409	.7633	25830	.7881	25263	.8134	24706	.8392	24159	.8655	1
	26399	.7637	25821	.7885	25253	.8138	24696	.8396	24150	.8659	
30	26389	.7641	25811	.7889	25244	.8143	24687	.8401	24141	.8663	0
'	A	B	A	B	A	B	A	B	A	B	'
	147°00'		146°30'		146°00'		145°30'		145°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	35°00' A	B	35°30' A	B	36°00' A	B	36°30' A	B	37°00' A	B	'
0	24141	.8663	23605	.8931	23078	.9204	22561	.9482	22054	.9765	30
	24132	.8668	23596	.8936	23069	.9209	22553	.9487	22045	.9770	
1	24123	.8672	23587	.8940	23061	.9213	22544	.9492	22037	.9775	29
	24114	.8677	23578	.8945	23052	.9218	22536	.9496	22029	.9779	
2	24105	.8681	23569	.8949	23043	.9223	22527	.9501	22020	.9784	28
	24096	.8686	23560	.8954	23035	.9227	22519	.9505	22012	.9789	
3	24087	.8690	23551	.8958	23026	.9232	22510	.9510	22003	.9794	27
	24078	.8694	23543	.8963	23017	.9236	22501	.9515	21995	.9798	
4	24069	.8699	23534	.8967	23009	.9241	22493	.9520	21987	.9803	26
	24060	.8703	23525	.8972	23000	.9246	22484	.9524	21978	.9808	
5	24051	.8708	23516	.8976	22991	.9250	22476	.9529	21970	.9813	25
	24042	.8712	23507	.8981	22983	.9255	22467	.9534	21962	.9818	
6	24033	.8717	23498	.8986	22974	.9259	22459	.9538	21953	.9822	24
	24024	.8721	23490	.8990	22965	.9264	22450	.9543	21945	.9827	
7	24015	.8726	23481	.8995	22957	.9269	22442	.9548	21937	.9832	23
	24006	.8730	23472	.8999	22948	.9273	22433	.9552	21928	.9837	
8	23997	.8734	23463	.9004	22939	.9278	22425	.9557	21920	.9841	22
	23988	.8739	23454	.9008	22931	.9282	22416	.9562	21912	.9846	
9	23979	.8743	23446	.9013	22922	.9287	22408	.9566	21903	.9851	21
	23970	.8748	23437	.9017	22913	.9292	22399	.9571	21895	.9856	
10	23961	.8752	23428	.9022	22905	.9296	22391	.9576	21887	.9861	20
	23952	.8757	23419	.9026	22896	.9301	22382	.9581	21878	.9865	
11	23943	.8761	23410	.9031	22887	.9305	22374	.9585	21870	.9870	19
	23934	.8766	23402	.9035	22879	.9310	22366	.9590	21862	.9875	
12	23925	.8770	23393	.9040	22870	.9315	22357	.9595	21853	.9880	18
	23916	.8775	23384	.9044	22862	.9319	22349	.9599	21845	.9885	
13	23907	.8779	23375	.9049	22853	.9324	22340	.9604	21837	.9889	17
	23898	.8783	23366	.9054	22844	.9329	22332	.9609	21828	.9894	
14	23889	.8788	23358	.9058	22836	.9333	22323	.9614	21820	.9899	16
	23880	.8792	23349	.9063	22827	.9338	22315	.9618	21812	.9904	
15	23871	.8797	23340	.9067	22818	.9342	22306	.9623	21803	.9909	15
	23863	.8801	23331	.9072	22810	.9347	22298	.9628	21795	.9913	
16	23854	.8806	23323	.9076	22801	.9352	22289	.9632	21787	.9918	14
	23845	.8810	23314	.9081	22793	.9356	22281	.9637	21778	.9923	
17	23836	.8815	23305	.9085	22784	.9361	22272	.9642	21770	.9928	13
	23827	.8819	23296	.9090	22775	.9366	22264	.9647	21762	.9933	
18	23818	.8824	23288	.9094	22767	.9370	22256	.9651	21754	.9937	12
	23809	.8828	23279	.9099	22758	.9375	22247	.9656	21745	.9942	
19	23800	.8833	23270	.9104	22750	.9380	22239	.9661	21737	.9947	11
	23791	.8837	23261	.9108	22741	.9384	22230	.9665	21729	.9952	
20	23782	.8842	23252	.9113	22732	.9389	22222	.9670	21720	.9957	10
	23773	.8846	23244	.9117	22724	.9394	22213	.9675	21712	.9962	
21	23764	.8850	23235	.9122	22715	.9398	22205	.9680	21704	.9966	9
	23755	.8855	23226	.9126	22707	.9403	22197	.9684	21696	.9971	
22	23747	.8859	23218	.9131	22698	.9407	22188	.9689	21687	.9976	8
	23738	.8864	23209	.9136	22690	.9412	22180	.9694	21679	.9981	
23	23729	.8868	23200	.9140	22681	.9417	22171	.9699	21671	.9986	7
	23720	.8873	23191	.9145	22672	.9421	22168	.9703	21662	.9990	
24	23711	.8877	23183	.9149	22664	.9426	22154	.9708	21654	.9995	6
	23702	.8882	23174	.9154	22655	.9431	22146	.9713	21646	.10000	
25	23693	.8886	23165	.9158	22647	.9435	22138	.9718	21638	.10005	5
	23684	.8891	23156	.9163	22638	.9440	22129	.9722	21629	.10010	
26	23675	.8895	23148	.9168	22630	.9445	22121	.9727	21621	.10015	4
	23667	.8900	23139	.9172	22621	.9449	22112	.9732	21613	.10019	
27	23658	.8904	23130	.9177	22612	.9454	22104	.9737	21605	.10024	3
	23649	.8909	23122	.9181	22604	.9459	22096	.9741	21596	.10029	
28	23640	.8913	23113	.9186	22595	.9463	22087	.9746	21588	.10034	2
	23631	.8918	23104	.9190	22587	.9468	22079	.9751	21580	.10039	
29	23622	.8922	23095	.9195	22578	.9473	22070	.9756	21572	.10044	1
	23613	.8927	23087	.9200	22570	.9477	22062	.9760	21563	.10049	
30	23605	.8931	23078	.9204	22561	.9482	22054	.9765	21555	.10053	0
	A	B	A	B	A	B	A	B	A	B	'
	144°30'		144°00'		143°30'		143°00'		142°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	37°30'		38°00'		38°30'		39°00'		39°30'		
'	A	B	A	B	A	B	A	B	A	B	
0	21555	10053	21066	10347	20585	10646	20113	10950	19649	11259	30
	21547	10058	21058	10352	20577	10651	20105	10955	19641	11265	
1	21539	10063	21050	10357	20569	10656	20097	10960	19634	11270	29
	21531	10068	21042	10362	20561	10661	20089	10965	19626	11275	
2	21522	10073	21033	10367	20553	10666	20082	10970	19618	11280	28
	21514	10078	21025	10372	20545	10671	20074	10975	19611	11285	
3	21506	10082	21017	10376	20537	10676	20066	10980	19603	11291	27
	21498	10087	21009	10381	20529	10681	20058	10986	19595	11296	
4	21489	10092	21001	10386	20522	10686	20050	10991	19588	11301	26
	21481	10097	20993	10391	20514	10691	20043	10996	19580	11306	
5	21473	10102	20985	10396	20506	10696	20035	11001	19572	11311	25
	21465	10107	20977	10401	20498	10701	20027	11006	19565	11317	
6	21457	10112	20969	10406	20490	10706	20019	11011	19557	11322	24
	21448	10116	20961	10411	20482	10711	20012	11016	19549	11327	
7	21440	10121	20953	10416	20474	10716	20004	11021	19541	11332	23
	21432	10126	20945	10421	20466	10721	19996	11027	19534	11338	
8	21424	10131	20937	10426	20458	10726	19988	11032	19527	11343	22
	21416	10136	20929	10431	20450	10731	19980	11037	19519	11348	
9	21407	10141	20921	10436	20442	10736	19973	11042	19511	11353	21
	21399	10146	20913	10441	20435	10741	19965	11047	19504	11359	
10	21391	10151	20905	10446	20427	10746	19957	11052	19496	11364	20
	21383	10155	20897	10451	20419	10751	19949	11057	19488	11369	
11	21375	10160	20888	10456	20411	10756	19942	11063	19481	11374	19
	21367	10165	20880	10461	20403	10761	19934	11068	19473	11380	
12	21358	10170	20872	10466	20395	10767	19926	11073	19466	11385	18
	21350	10175	20864	10471	20387	10772	19919	11078	19458	11390	
13	21342	10180	20856	10476	20379	10777	19911	11083	19450	11395	17
	21334	10185	20848	10481	20371	10782	19903	11088	19443	11400	
14	21326	10190	20840	10486	20364	10787	19895	11094	19435	11406	16
	21318	10195	20832	10491	20356	10792	19888	11099	19428	11411	
15	21309	10199	20824	10496	20348	10797	19880	11104	19420	11416	15
	21301	10204	20816	10500	20340	10802	19872	11109	19412	11422	
16	21293	10209	20808	10505	20332	10807	19864	11114	19405	11427	14
	21285	10214	20800	10510	20324	10812	19857	11119	19397	11432	
17	21277	10219	20792	10515	20316	10817	19849	11124	19390	11437	13
	21269	10224	20784	10520	20309	10822	19841	11130	19382	11443	
18	21260	10229	20776	10525	20301	10827	19834	11135	19375	11448	12
	21252	10234	20768	10530	20293	10832	19826	11140	19367	11453	
19	21244	10239	20760	10535	20285	10838	19818	11145	19359	11458	11
	21236	10243	20752	10540	20277	10843	19810	11150	19352	11464	
20	21228	10248	20744	10545	20269	10848	19803	11156	19344	11469	10
	21220	10253	20736	10550	20261	10853	19795	11161	19337	11474	
21	21212	10258	20728	10555	20254	10858	19787	11166	19329	11479	9
	21204	10263	20720	10560	20246	10863	19779	11171	19321	11485	
22	21195	10268	20712	10565	20238	10868	19772	11176	19314	11490	8
	21187	10273	20704	10570	20230	10873	19764	11181	19306	11495	
23	21179	10278	20696	10575	20222	10878	19756	11187	19299	11501	7
	21171	10283	20688	10580	20214	10883	19749	11192	19291	11506	
24	21163	10288	20680	10585	20207	10888	19741	11197	19284	11511	6
	21155	10293	20672	10590	20199	10894	19733	11202	19276	11516	
25	21147	10298	20665	10595	20191	10899	19726	11207	19269	11522	5
	21139	10302	20657	10600	20183	10904	19718	11213	19261	11527	
26	21131	10307	20649	10605	20175	10909	19710	11218	19253	11532	4
	21122	10312	20641	10610	20167	10914	19703	11223	19246	11537	
27	21114	10317	20633	10615	20160	10919	19695	11228	19238	11543	3
	21106	10322	20625	10620	20152	10924	19687	11233	19231	11548	
28	21098	10327	20617	10625	20144	10929	19680	11239	19223	11553	2
	21090	10332	20609	10630	20136	10934	19672	11244	19216	11559	
29	21082	10337	20601	10635	20128	10939	19664	11249	19208	11564	1
	21074	10342	20593	10640	20121	10945	19657	11254	19201	11569	
30	21066	10347	20585	10646	20113	10950	19649	11259	19193	11575	0
'	A	B	A	B	A	B	A	B	A	B	'
	142°00'		141°30'		141°00'		140°30'		140°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	40°00' A	B	40°30' A	B	41°00' A	B	41°30' A	B	42°00' A	B	'
0	19193	11575	18746	11895	18306	12222	17873	12554	17449	12893	30
	19186	11580	18738	11901	18298	12228	17866	12560	17442	12898	
1	19178	11585	18731	11906	18291	12233	17859	12566	17435	12904	29
	19171	11590	18723	11912	18284	12238	17852	12571	17428	12910	
2	19163	11596	18716	11917	18277	12244	17845	12577	17421	12915	28
	19156	11601	18709	11922	18269	12249	17838	12582	17414	12921	
3	19148	11606	18701	11928	18262	12255	17831	12588	17407	12927	27
	19141	11612	18694	11933	18255	12260	17824	12593	17400	12932	
4	19133	11617	18686	11939	18248	12266	17816	12599	17393	12938	26
	19126	11622	18679	11944	18240	12271	17809	12605	17286	12944	
5	19118	11628	18672	11949	18233	12277	17802	12610	17379	12950	25
	19111	11633	18664	11955	18226	12282	17795	12616	17372	12955	
6	19103	11638	18657	11960	18219	12288	17788	12622	17365	12961	24
	19096	11644	18650	11966	18211	12293	17781	12627	17358	12967	
7	19088	11649	18642	11971	18204	12299	17774	12633	17351	12972	23
	19081	11654	18635	11977	18197	12305	17767	12638	17344	12978	
8	19073	11660	18627	11982	18190	12310	17760	12644	17337	12984	22
	19066	11665	18620	11987	18182	12316	17752	12650	17330	12990	
9	19058	11670	18613	11993	18175	12321	17745	12655	17323	12995	21
	19051	11676	18605	11998	18168	12327	17738	12661	17316	13001	
10	19043	11681	18598	12004	18161	12332	17731	12667	17309	13007	20
	19036	11686	18591	12009	18154	12338	17724	12672	17302	13012	
11	19028	11692	18583	12014	18146	12343	17717	12678	17295	13018	19
	19021	11697	18576	12020	18139	12349	17710	12683	17288	13024	
12	19013	11702	18569	12025	18132	12354	17703	12689	17281	13030	18
	19006	11708	18561	12031	18125	12360	17696	12695	17274	13035	
13	18998	11713	18554	12036	18117	12365	17689	12700	17267	13041	17
	18991	11718	18547	12042	18110	12371	17681	12706	17260	13047	
14	18983	11724	18539	12047	18103	12376	17674	12711	17253	13053	16
	18976	11729	18532	12053	18096	12382	17667	12717	17246	13058	
15	18968	11734	18525	12058	18089	12387	17660	12723	17239	13064	15
	18961	11740	18517	12063	18081	12393	17653	12728	17232	13070	
16	18953	11745	18510	12069	18074	12398	17646	12734	17225	13075	14
	18946	11750	18503	12074	18067	12404	17639	12740	17218	13081	
17	18939	11756	18495	12080	18060	12410	17632	12745	17212	13087	13
	18931	11761	18488	12085	18053	12415	17625	12751	17205	13093	
18	18924	11766	18481	12091	18045	12421	17618	12757	17198	13098	12
	18916	11772	18473	12096	18038	12426	17611	12762	17191	13104	
19	18909	11777	18466	12102	18031	12432	17604	12768	17184	13110	11
	18901	11782	18459	12107	18024	12437	17597	12774	17177	13116	
20	18894	11788	18451	12112	18017	12443	17590	12779	17170	13121	10
	18886	11793	18444	12118	18010	12448	17583	12785	17163	13127	
21	18879	11799	18437	12123	18002	12454	17575	12790	17156	13133	9
	18872	11804	18429	12129	17995	12460	17568	12796	17149	13139	
22	18864	11809	18422	12134	17988	12465	17561	12802	17142	13144	8
	18857	11815	18415	12140	17981	12471	17554	12807	17135	13150	
23	18849	11820	18408	12145	17974	12476	17547	12813	17128	13156	7
	18842	11825	18400	12151	17966	12482	17540	12819	17121	13162	
24	18834	11831	18393	12156	17959	12487	17533	12824	17114	13168	6
	18827	11836	18386	12162	17952	12493	17526	12830	17108	13173	
25	18820	11842	18378	12167	17945	12499	17519	12836	17107	13179	5
	18812	11847	18371	12173	17938	12504	17512	12841	17094	13185	
26	18805	11852	18364	12178	17931	12510	17505	12847	17087	13191	4
	18797	11858	18357	12184	17924	12515	17498	12853	17080	13196	
27	18790	11863	18349	12189	17916	12521	17491	12859	17073	13202	3
	18783	11868	18342	12195	17909	12526	17484	12864	17066	13208	
28	18775	11874	18335	12200	17902	12532	17477	12870	17059	13214	2
	18768	11879	18327	12205	17895	12538	17470	12876	17052	13220	
29	18760	11885	18320	12211	17888	12543	17463	12881	17046	13225	1
	18753	11890	18313	12216	17881	12549	17456	12887	17039	13231	
30	18746	11895	18306	12222	17873	12554	17449	12893	17032	13237	0
'	A	B	A	B	A	B	A	B	A	B	'
	139°30'		139°00'		138°30'		138°00'		137°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	42°30'		43°00'		43°30'		44°00'		44°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	17032	13237	16622	13587	16219	13944	15823	14307	15434	14676	30
	17025	13243	16615	13593	16212	13950	15816	14313	15427	14682	
1	17018	13248	16608	13599	16205	13956	15810	14319	15421	14688	29
	17011	13254	16601	13605	16199	13962	15803	14325	15414	14694	
2	17004	13260	16595	13611	16192	13968	15797	14331	15408	14701	28
	16997	13266	16588	13617	16186	13974	15790	14337	15402	14707	
3	16990	13272	16581	13623	16179	13980	15784	14343	15395	14713	27
	16983	13277	16574	13628	16172	13986	15777	14349	15389	14719	
4	16977	13283	16567	13634	16166	13992	15771	14355	15382	14726	26
	16970	13289	16561	13640	16159	13998	15764	14362	15376	14732	
5	16963	13295	16554	13646	16152	14004	15758	14368	15370	14738	25
	16956	13301	16547	13652	16146	14010	15751	14374	15363	14744	
6	16949	13306	16540	13658	16139	14016	15744	14380	15357	14750	24
	16942	13312	16534	13664	16132	14022	15738	14386	15350	14757	
7	16935	13318	16527	13670	16126	14028	15731	14392	15344	14763	23
	16928	13324	16520	13676	16119	14034	15725	14398	15338	14769	
8	16922	13330	16513	13682	16112	14040	15718	14404	15331	14775	22
	16915	13336	16507	13688	16106	14046	15712	14411	15325	14782	
9	16908	13341	16500	13694	16099	14052	15705	14417	15318	14788	21
	16901	13347	16493	13700	16093	14058	15699	14423	15312	14794	
10	16894	13353	16487	13705	16086	14064	15692	14429	15306	14800	20
	16887	13359	16480	13711	16079	14070	15686	14435	15299	14807	
11	16880	13365	16473	13717	16073	14076	15679	14441	15293	14813	19
	16874	13370	16466	13723	16066	14082	15673	14447	15286	14819	
12	16867	13376	16460	13729	16060	14088	15666	14453	15280	14825	18
	16860	13382	16453	13735	16053	14094	15660	14460	15274	14831	
13	16853	13388	16446	13741	16046	14100	15653	14466	15267	14838	17
	16846	13394	16439	13747	16040	14106	15647	14472	15261	14844	
14	16839	13400	16433	13753	16033	14112	15640	14478	15255	14850	16
	16833	13405	16426	13759	16027	14118	15634	14484	15248	14857	
15	16826	13411	16419	13765	16020	14124	15627	14490	15242	14863	15
	16819	13417	16413	13771	16013	14130	15621	14496	15235	14869	
16	16812	13423	16406	13777	16007	14136	15614	14503	15229	14875	14
	16805	13429	16399	13783	16000	14142	15608	14509	15223	14882	
17	16798	13435	16392	13789	15994	14149	15602	14515	15216	14888	13
	16792	13440	16386	13794	15987	14155	15595	14521	15210	14894	
18	16785	13446	16379	13800	15980	14161	15589	14527	15204	14900	12
	16778	13452	16372	13806	15974	14167	15582	14533	15197	14907	
19	16771	13458	16366	13812	15967	14173	15576	14540	15191	14913	11
	16764	13464	16359	13818	15961	14179	15569	14546	15184	14919	
20	16757	13470	16352	13824	15954	14185	15563	14552	15178	14925	10
	16751	13476	16346	13830	15947	14191	15556	14558	15172	14932	
21	16744	13481	16339	13836	15941	14197	15550	14564	15165	14938	9
	16737	13487	16332	13842	15934	14203	15543	14570	15159	14944	
22	16730	13493	16325	13848	15928	14209	15537	14577	15153	14951	8
	16723	13499	16319	13854	15921	14215	15530	14583	15146	14957	
23	16717	13505	16312	13860	15915	14221	15524	14589	15140	14963	7
	16710	13511	16305	13866	15908	14227	15517	14595	15134	14969	
24	16703	13517	16299	13872	15901	14233	15511	14601	15127	14976	6
	16696	13523	16292	13878	15895	14240	15505	14608	15121	14982	
25	16689	13528	16285	13884	15888	14246	15498	14614	15115	14988	5
	16683	13534	16279	13890	15882	14252	15492	14620	15108	14995	
26	16676	13540	16272	13896	15875	14258	15485	14626	15102	15001	4
	16669	13546	16265	13902	15869	14264	15479	14632	15096	15007	
27	16662	13552	16259	13908	15862	14270	15472	14639	15089	15014	3
	16656	13558	16252	13914	15856	14276	15466	14645	15083	15020	
28	16649	13564	16245	13920	15849	14282	15459	14651	15077	15026	2
	16642	13570	16239	13926	15842	14288	15453	14657	15070	15033	
29	16635	13575	16232	13932	15836	14294	15447	14663	15064	15039	1
	16628	13581	16225	13938	15829	14300	15440	14670	15058	15045	
30	16622	13587	16219	13944	15823	14307	15434	14676	15051	15051	0
'	A	B	A	B	A	B	A	B	A	B	'
	137°00'		136°30'		136°00'		135°30'		135°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	45°00' A	45°00' B	45°30' A	45°30' B	46°00' A	46°00' B	46°30' A	46°30' B	47°00' A	47°00' B	'
0	15051	15051	14676	15434	14307	15823	13944	16219	13587	16622	30
	15045	15058	14670	15440	14300	15829	13938	16225	13581	16628	
1	15039	15064	14663	15447	14294	15836	13932	16232	13575	16635	29
	15033	15070	14657	15453	14288	15842	13926	16239	13570	16642	
2	15026	15077	14651	15459	14282	15849	13920	16245	13564	16649	28
	15020	15083	14645	15466	14276	15856	13914	16252	13558	16656	
3	15014	15089	14639	15472	14270	15862	13908	16259	13552	16662	27
	15007	15096	14632	15479	14264	15869	13902	16265	13546	16669	
4	15001	15102	14626	15485	14258	15875	13896	16272	13540	16676	26
	14995	15108	14620	15492	14252	15882	13890	16279	13534	16683	
5	14988	15115	14614	15498	14246	15888	13884	16285	13528	16689	25
	14982	15121	14608	15505	14240	15895	13878	16292	13523	16696	
6	14976	15127	14601	15511	14233	15901	13872	16299	13517	16703	24
	14969	15134	14595	15517	14227	15908	13866	16305	13511	16710	
7	14963	15140	14589	15524	14221	15915	13860	16312	13505	16717	23
	14957	15146	14583	15530	14215	15921	13854	16319	13499	16723	
8	14951	15153	14577	15537	14209	15928	13848	16325	13493	16730	22
	14944	15159	14570	15543	14203	15934	13842	16332	13487	16737	
9	14938	15165	14564	15550	14197	15941	13836	16339	13481	16744	21
	14932	15172	14558	15556	14191	15947	13830	16346	13476	16751	
10	14925	15178	14552	15563	14185	15954	13824	16352	13470	16757	20
	14919	15184	14546	15569	14179	15961	13818	16359	13464	16764	
11	14913	15191	14540	15576	14173	15967	13812	16366	13458	16771	19
	14907	15197	14533	15582	14167	15974	13806	16372	13452	16778	
12	14900	15204	14527	15589	14161	15980	13800	16379	13446	16785	18
	14894	15210	14521	15595	14155	15987	13794	16386	13440	16792	
13	14888	15216	14515	15602	14149	15994	13788	16392	13435	16798	17
	14882	15223	14509	15608	14142	16000	13783	16399	13429	16805	
14	14875	15229	14503	15614	14136	16007	13777	16406	13423	16812	16
	14869	15235	14496	15621	14130	16013	13771	16413	13417	16819	
15	14863	15242	14490	15627	14124	16020	13765	16419	13411	16836	15
	14857	15248	14484	15634	14118	16027	13759	16426	13405	16833	
16	14850	15255	14478	15640	14112	16033	13753	16433	13400	16839	14
	14844	15261	14472	15647	14106	16040	13747	16439	13394	16846	
17	14838	15267	14466	15653	14100	16046	13741	16446	13388	16853	13
	14831	15274	14460	15660	14094	16053	13735	16453	13382	16860	
18	14825	15280	14453	15666	14088	16060	13729	16460	13376	16867	12
	14819	15286	14447	15673	14082	16066	13723	16466	13370	16874	
19	14813	15293	14441	15679	14076	16073	13717	16473	13365	16880	11
	14807	15299	14435	15686	14070	16079	13711	16480	13359	16887	
20	14800	15306	14429	15692	14064	16086	13705	16487	13353	16894	10
	14794	15312	14423	15699	14058	16093	13699	16493	13347	16901	
21	14788	15318	14417	15705	14052	16099	13694	16500	13341	16908	9
	14782	15325	14411	15712	14046	16105	13688	16507	13336	16915	
22	14775	15331	14404	15718	14040	16112	13682	16513	13330	16922	8
	14769	15338	14398	15725	14034	16119	13676	16520	13324	16928	
23	14763	15344	14392	15731	14028	16126	13670	16527	13318	16935	7
	14757	15350	14386	15738	14022	16132	13664	16534	13312	16942	
24	14750	15357	14380	15744	14016	16139	13658	16540	13306	16949	6
	14744	15363	14374	15751	14010	16146	13652	16547	13301	16956	
25	14738	15370	14368	15758	14004	16152	13646	16554	13295	16963	5
	14732	15376	14362	15764	13998	16159	13640	16561	13289	16970	
26	14725	15382	14355	15771	13992	16166	13634	16567	13283	16977	4
	14719	15389	14349	15777	13986	16172	13628	16574	13277	16983	
27	14713	15395	14343	15784	13980	16179	13623	16581	13272	16990	3
	14707	15402	14337	15790	13974	16185	13617	16588	13266	16997	
28	14701	15408	14331	15797	13968	16192	13611	16595	13260	17004	2
	14694	15414	14325	15803	13962	16199	13605	16601	13254	17011	
29	14688	15421	14319	15810	13956	16205	13599	16608	13248	17018	1
	14682	15427	14313	15816	13950	16212	13593	16615	13243	17025	
30	14676	15434	14307	15823	13944	16219	13587	16622	13237	17032	0
	A	B	A	B	A	B	A	B	A	B	'
	134°30'		134°00'		133°30'		133°00'		132°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	47°30'		48°00'		48°30'		49°00'		49°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	13237	17032	12893	17449	12554	17873	12222	18306	11895	18746	30
	13231	17039	12887	17456	12549	17881	12216	18313	11890	18753	
1	13225	17045	12881	17463	12543	17888	12211	18320	11885	18760	29
	13220	17052	12876	17470	12538	17895	12205	18327	11879	18768	
2	13214	17059	12870	17477	12532	17902	12200	18335	11874	18775	28
	13208	17066	12864	17484	12526	17909	12195	18342	11868	18783	
3	13202	17073	12859	17491	12521	17916	12189	18349	11863	18790	27
	13196	17080	12853	17498	12515	17924	12184	18357	11858	18797	
4	13191	17087	12847	17505	12510	17931	12178	18364	11852	18805	26
	13185	17094	12841	17512	12504	17938	12173	18371	11847	18812	
5	13179	17101	12836	17519	12499	17945	12167	18378	11842	18820	25
	13173	17108	12830	17526	12493	17952	12162	18386	11836	18827	
6	13168	17114	12824	17533	12487	17959	12156	18393	11831	18834	24
	13162	17121	12819	17540	12482	17966	12151	18400	11825	18842	
7	13156	17128	12813	17547	12476	17974	12145	18408	11820	18849	23
	13150	17135	12807	17554	12471	17981	12140	18415	11815	18857	
8	13144	17142	12802	17561	12465	17988	12134	18422	11809	18864	22
	13139	17149	12796	17568	12460	17995	12129	18429	11804	18872	
9	13133	17156	12790	17576	12454	18002	12123	18437	11799	18879	21
	13127	17163	12785	17583	12448	18010	12118	18444	11793	18886	
10	13121	17170	12779	17590	12443	18017	12112	18451	11788	18894	20
	13116	17177	12774	17597	12437	18024	12107	18459	11782	18901	
11	13110	17184	12768	17604	12432	18031	12102	18466	11777	18909	19
	13104	17191	12762	17611	12426	18038	12096	18473	11772	18916	
12	13098	17198	12757	17618	12421	18045	12091	18481	11766	18924	18
	13093	17205	12751	17625	12415	18053	12085	18488	11761	18931	
13	13087	17212	12745	17632	12410	18060	12080	18495	11756	18939	17
	13081	17218	12740	17639	12404	18067	12074	18503	11750	18946	
14	13075	17225	12734	17646	12398	18074	12069	18510	11745	18953	16
	13070	17232	12728	17653	12393	18081	12063	18517	11740	18961	
15	13064	17239	12723	17660	12387	18089	12058	18525	11734	18968	15
	13058	17246	12717	17667	12382	18096	12053	18532	11729	18976	
16	13053	17253	12711	17674	12376	18103	12047	18539	11724	18983	14
	13047	17260	12706	17681	12371	18110	12042	18547	11718	18991	
17	13041	17267	12700	17689	12365	18117	12036	18554	11713	18998	13
	13035	17274	12695	17696	12360	18125	12031	18561	11708	19006	
18	13030	17281	12689	17703	12354	18132	12025	18569	11702	19013	12
	13024	17288	12683	17710	12349	18139	12020	18576	11697	19021	
19	13018	17295	12678	17717	12343	18146	12014	18583	11692	19028	11
	13012	17302	12672	17724	12338	18154	12009	18591	11686	19036	
20	13007	17309	12666	17731	12332	18161	12004	18598	11681	19043	10
	13001	17316	12661	17738	12327	18168	11998	18605	11676	19051	
21	12995	17323	12655	17745	12321	18175	11993	18613	11670	19058	9
	12990	17330	12650	17752	12316	18182	11987	18620	11665	19066	
22	12984	17337	12644	17760	12310	18190	11982	18627	11660	19073	8
	12978	17344	12638	17767	12305	18197	11976	18635	11654	19081	
23	12972	17351	12633	17774	12299	18204	11971	18642	11649	19088	7
	12967	17358	12627	17781	12293	18211	11966	18650	11644	19096	
24	12961	17365	12622	17788	12288	18219	11960	18657	11638	19103	6
	12955	17372	12616	17795	12282	18226	11955	18664	11633	19111	
25	12950	17379	12610	17802	12277	18233	11949	18672	11628	19118	5
	12944	17386	12605	17809	12271	18240	11944	18679	11622	19126	
26	12938	17393	12599	17816	12266	18248	11939	18686	11617	19133	4
	12932	17400	12593	17824	12260	18255	11933	18694	11612	19141	
27	12927	17407	12588	17831	12255	18262	11928	18701	11606	19148	3
	12921	17414	12582	17838	12249	18269	11922	18709	11601	19156	
28	12915	17421	12577	17845	12244	18277	11917	18716	11596	19163	2
	12910	17428	12571	17852	12238	18284	11912	18723	11590	19171	
29	12904	17435	12566	17859	12233	18291	11906	18731	11585	19178	1
	12898	17442	12560	17866	12227	18298	11901	18738	11580	19186	
30	12893	17449	12554	17873	12222	18306	11895	18746	11575	19193	0
'	A	B	A	B	A	B	A	B	A	B	'
	132°00'		131°30'		131°00'		130°30'		130°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	50°00'		50°30'		51°00'		51°30'		52°00'		'
	A	B	A	B	A	B	A	B	A	B	
0	11575	19193	11259	19649	10950	20113	10646	20585	10347	21066	30
	11569	19201	11254	19657	10945	20121	10640	20593	10342	21074	
1	11564	19208	11249	19664	10939	20128	10635	20601	10337	21082	29
	11559	19216	11244	19672	10934	20136	10630	20609	10332	21090	
2	11553	19223	11239	19680	10929	20144	10625	20617	10327	21098	28
	11548	19231	11233	19687	10924	20152	10620	20625	10322	21106	
3	11543	19238	11228	19695	10919	20160	10615	20633	10317	21114	27
	11537	19246	11223	19703	10914	20167	10610	20641	10312	21122	
4	11532	19253	11218	19710	10909	20175	10605	20649	10307	21131	26
	11527	19261	11213	19718	10904	20183	10600	20657	10302	21139	
5	11522	19269	11207	19726	10899	20191	10595	20665	10298	21147	25
	11516	19276	11202	19733	10894	20199	10590	20672	10293	21155	
6	11511	19284	11197	19741	10888	20207	10585	20680	10288	21163	24
	11506	19291	11192	19749	10883	20214	10580	20688	10283	21171	
7	11501	19299	11187	19756	10878	20222	10575	20696	10278	21179	23
	11495	19306	11181	19764	10873	20230	10570	20704	10273	21187	
8	11490	19314	11176	19772	10868	20238	10565	20712	10268	21195	22
	11485	19321	11171	19779	10863	20246	10560	20720	10263	21204	
9	11479	19329	11166	19787	10858	20254	10555	20728	10258	21212	21
	11474	19337	11161	19795	10853	20261	10550	20736	10253	21220	
10	11469	19344	11156	19803	10848	20269	10545	20744	10248	21228	20
	11464	19352	11150	19810	10843	20277	10540	20752	10243	21236	
11	11458	19359	11145	19818	10838	20285	10535	20760	10239	21244	19
	11453	19367	11140	19826	10832	20293	10530	20768	10234	21252	
12	11448	19375	11135	19834	10827	20301	10525	20776	10229	21260	18
	11443	19382	11130	19841	10822	20308	10520	20784	10224	21269	
13	11437	19390	11124	19849	10817	20316	10515	20792	10219	21277	17
	11432	19397	11119	19857	10812	20324	10510	20800	10214	21285	
14	11427	19405	11114	19864	10807	20332	10505	20808	10209	21293	16
	11421	19412	11109	19872	10802	20340	10500	20816	10204	21301	
15	11416	19420	11104	19880	10797	20348	10496	20824	10199	21309	15
	11411	19428	11099	19888	10792	20356	10491	20832	10195	21318	
16	11406	19435	11094	19895	10787	20364	10486	20840	10190	21326	14
	11400	19443	11088	19903	10782	20371	10481	20848	10185	21334	
17	11395	19450	11083	19911	10777	20379	10476	20856	10180	21342	13
	11390	19458	11078	19918	10772	20387	10471	20864	10175	21350	
18	11385	19466	11073	19926	10767	20395	10466	20872	10170	21358	12
	11380	19473	11068	19934	10761	20403	10461	20880	10165	21367	
19	11374	19481	11063	19942	10756	20411	10456	20888	10160	21375	11
	11369	19488	11057	19949	10751	20419	10451	20897	10155	21383	
20	11364	19496	11052	19957	10746	20427	10446	20905	10151	21391	10
	11359	19504	11047	19965	10741	20435	10441	20913	10146	21399	
21	11353	19511	11042	19973	10736	20442	10436	20921	10141	21407	9
	11348	19519	11037	19980	10731	20450	10431	20929	10136	21416	
22	11343	19527	11032	19988	10726	20458	10426	20937	10131	21424	8
	11338	19534	11027	19996	10721	20466	10421	20945	10126	21432	
23	11332	19542	11021	20004	10716	20474	10416	20953	10121	21440	7
	11327	19549	11016	20012	10711	20482	10411	20961	10116	21448	
24	11322	19557	11011	20019	10706	20490	10406	20969	10112	21457	6
	11317	19565	11006	20027	10701	20498	10401	20977	10107	21465	
25	11311	19572	11001	20035	10696	20506	10396	20985	10102	21473	5
	11306	19580	10996	20043	10691	20514	10391	20993	10097	21481	
26	11301	19588	10991	20050	10686	20522	10386	21001	10092	21489	4
	11296	19595	10986	20058	10681	20529	10381	21009	10087	21498	
27	11291	19603	10980	20066	10676	20537	10376	21017	10082	21506	3
	11285	19611	10975	20074	10671	20545	10372	21025	10078	21514	
28	11280	19618	10970	20082	10666	20553	10367	21033	10073	21522	2
	11275	19626	10965	20089	10661	20561	10362	21042	10068	21531	
29	11270	19634	10960	20097	10656	20569	10357	21050	10063	21539	1
	11265	19641	10955	20105	10651	20577	10352	21058	10058	21547	
30	11259	19649	10950	20113	10646	20585	10347	21066	10053	21555	0
'	A	B	A	B	A	B	A	B	A	B	'
	129°30'		129°00'		128°30'		128°00'		127°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	52°30'		53°00'		53°30'		54°00'		54°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	10053	21555	9765	22054	9482	22561	9204	23078	8931	23605	30
	10049	21563	9760	22062	9477	22570	9200	23087	8927	23613	
1	10044	21572	9756	22070	9473	22578	9195	23095	8922	23622	29
	10039	21580	9751	22079	9468	22587	9190	23104	8918	23631	
2	10034	21588	9746	22087	9463	22595	9186	23113	8913	23640	28
	10029	21596	9741	22096	9459	22604	9181	23122	8909	23649	
3	10024	21605	9737	22104	9454	22612	9177	23130	8904	23658	27
	10019	21613	9732	22112	9449	22621	9172	23139	8900	23667	
4	10015	21621	9727	22121	9445	22630	9168	23148	8895	23675	26
	10010	21629	9722	22129	9440	22638	9163	23156	8891	23684	
5	10005	21638	9718	22138	9435	22647	9158	23165	8886	23693	25
	10000	21646	9713	22146	9431	22655	9154	23174	8882	23702	
6	9995	21654	9708	22154	9426	22664	9149	23183	8877	23711	24
	9990	21662	9703	22163	9421	22672	9145	23191	8873	23720	
7	9986	21671	9699	22171	9417	22681	9140	23200	8868	23729	23
	9981	21679	9694	22180	9412	22690	9136	23209	8864	23738	
8	9976	21687	9689	22188	9407	22698	9131	23218	8859	23747	22
	9971	21696	9684	22197	9403	22707	9126	23226	8855	23755	
9	9966	21704	9680	22205	9398	22715	9122	23235	8850	23764	21
	9962	21712	9675	22213	9394	22724	9117	23244	8846	23773	
10	9957	21720	9670	22222	9389	22732	9113	23252	8842	23782	20
	9952	21729	9665	22230	9384	22741	9108	23261	8837	23791	
11	9947	21737	9661	22239	9380	22750	9104	23270	8833	23800	19
	9942	21745	9656	22247	9375	22758	9099	23279	8828	23809	
12	9937	21754	9651	22256	9370	22767	9094	23288	8824	23818	18
	9933	21762	9647	22264	9366	22775	9090	23296	8819	23827	
13	9928	21770	9642	22272	9361	22784	9085	23305	8815	23836	17
	9923	21778	9637	22281	9356	22793	9081	23314	8810	23845	
14	9918	21787	9632	22289	9352	22801	9076	23323	8806	23854	16
	9913	21795	9628	22298	9347	22810	9072	23331	8801	23863	
15	9909	21803	9623	22306	9342	22818	9067	23340	8797	23871	15
	9904	21812	9618	22315	9338	22827	9063	23349	8792	23880	
16	9899	21820	9614	22323	9333	22836	9058	23358	8788	23889	14
	9894	21828	9609	22332	9329	22844	9054	23366	8783	23898	
17	9889	21837	9604	22340	9324	22853	9049	23375	8779	23907	13
	9885	21845	9599	22349	9319	22862	9044	23384	8775	23916	
18	9880	21853	9595	22357	9315	22870	9040	23393	8770	23925	12
	9875	21862	9590	22366	9310	22879	9035	23402	8766	23934	
19	9870	21870	9585	22374	9305	22887	9031	23410	8761	23943	11
	9865	21878	9581	22382	9301	22896	9026	23419	8757	23952	
20	9861	21887	9576	22391	9296	22905	9022	23428	8752	23961	10
	9856	21895	9571	22399	9292	22913	9017	23437	8748	23970	
21	9851	21903	9566	22408	9287	22922	9013	23446	8743	23979	9
	9846	21912	9562	22416	9282	22931	9008	23454	8739	23988	
22	9841	21920	9557	22425	9278	22939	9004	23463	8734	23997	8
	9837	21928	9552	22433	9273	22948	8999	23472	8730	24006	
23	9832	21937	9548	22442	9269	22957	8995	23481	8726	24015	7
	9827	21945	9543	22450	9264	22965	8990	23490	8721	24024	
24	9822	21953	9538	22459	9259	22974	8985	23498	8717	24033	6
	9818	21962	9534	22467	9255	22983	8981	23507	8712	24042	
25	9813	21970	9529	22476	9250	22991	8976	23516	8708	24051	5
	9808	21978	9524	22484	9246	23000	8972	23525	8703	24060	
26	9803	21987	9520	22493	9241	23009	8967	23534	8699	24069	4
	9798	21995	9515	22501	9236	23017	8963	23543	8694	24078	
27	9794	22003	9510	22510	9232	23026	8958	23551	8690	24037	3
	9789	22012	9505	22519	9227	23035	8954	23560	8686	24096	
28	9784	22020	9501	22527	9223	23043	8949	23569	8681	24105	2
	9779	22029	9496	22536	9218	23052	8945	23578	8677	24114	
29	9775	22037	9491	22544	9213	23061	8940	23587	8672	24123	1
	9770	22045	9487	22553	9209	23069	8936	23596	8668	24132	
30	9765	22054	9482	22561	9204	23078	8931	23605	8663	24141	0
'	A	B	A	B	A	B	A	B	A	B	'
	127°00'		126°30'		126°00'		125°30'		125°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	55°00'		55°30'		56°00'		56°30'		57°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	8663	.24141	8401	.24687	8143	.25244	7889	.25811	7641	.26389	30
	8659	.24150	8396	.24696	8138	.25253	7885	.25821	7637	.26399	
1	8655	.24159	8392	.24706	8134	.25263	7881	.25830	7633	.26409	29
	8650	.24168	8388	.24715	8130	.25272	7877	.25840	7629	.26418	
2	8646	.24177	8383	.24724	8125	.25281	7873	.25849	7624	.26428	27
	8641	.24186	8379	.24733	8121	.25291	7868	.25859	7620	.26438	
3	8637	.24195	8375	.24742	8117	.25300	7864	.25868	7616	.26447	27
	8633	.24204	8370	.24752	8113	.25309	7860	.25878	7612	.26457	
4	8628	.24213	8366	.24761	8108	.25319	7856	.25887	7608	.26467	26
	8624	.24222	8362	.24770	8104	.25328	7852	.25897	7604	.26477	
5	8619	.24231	8357	.24779	8100	.25338	7848	.25907	7600	.26486	25
	8615	.24240	8353	.24788	8096	.25347	7843	.25916	7596	.26496	
6	8611	.24249	8349	.24798	8092	.25356	7839	.25926	7592	.26506	24
	8606	.24258	8344	.24807	8087	.25366	7835	.25935	7588	.26516	
7	8602	.24267	8340	.24816	8083	.25375	7831	.25945	7584	.26526	23
	8597	.24276	8336	.24825	8079	.25385	7827	.25954	7579	.26535	
8	8593	.24286	8331	.24835	8075	.25394	7823	.25964	7575	.26545	22
	8589	.24295	8327	.24844	8070	.25403	7818	.25974	7571	.26555	
9	8584	.24304	8323	.24853	8066	.25413	7814	.25983	7567	.26565	21
	8580	.24313	8318	.24862	8062	.25422	7810	.25993	7563	.26574	
10	8575	.24322	8314	.24872	8058	.25432	7806	.26002	7559	.26584	20
	8571	.24331	8310	.24881	8053	.25441	7802	.26012	7555	.26594	
11	8567	.24340	8305	.24890	8049	.25451	7798	.26022	7551	.26604	19
	8562	.24349	8301	.24899	8045	.25460	7793	.26031	7547	.26614	
12	8558	.24358	8297	.24909	8041	.25469	7789	.26041	7543	.26623	18
	8553	.24367	8292	.24918	8036	.25479	7785	.26051	7539	.26633	
13	8549	.24376	8288	.24927	8032	.25488	7781	.26060	7535	.26643	17
	8545	.24385	8284	.24936	8028	.25498	7777	.26070	7531	.26653	
14	8540	.24395	8280	.24946	8024	.25507	7773	.26079	7526	.26663	16
	8536	.24404	8275	.24955	8020	.25517	7769	.26089	7522	.26672	
15	8531	.24413	8271	.24964	8015	.25526	7764	.26099	7518	.26682	15
	8527	.24422	8267	.24973	8011	.25536	7760	.26108	7514	.26692	
16	8523	.24431	8262	.24983	8007	.25545	7756	.26118	7510	.26702	14
	8518	.24440	8258	.24992	8003	.25554	7752	.26128	7506	.26712	
17	8514	.24449	8254	.25001	7998	.25564	7748	.26137	7502	.26722	13
	8510	.24458	8249	.25011	7994	.25573	7744	.26147	7498	.26731	
18	8505	.24467	8245	.25020	7990	.25583	7740	.26157	7494	.26741	12
	8501	.24477	8241	.25029	7986	.25592	7736	.26166	7490	.26751	
19	8496	.24486	8237	.25038	7982	.25602	7731	.26176	7486	.26761	11
	8492	.24495	8232	.25048	7977	.25611	7727	.26185	7482	.26771	
20	8488	.24504	8228	.25057	7973	.25621	7723	.26195	7478	.26781	10
	8483	.24513	8224	.25066	7969	.25630	7719	.26205	7474	.26790	
21	8479	.24522	8219	.25076	7965	.25640	7715	.26214	7470	.26800	9
	8475	.24531	8215	.25085	7961	.25649	7711	.26224	7466	.26810	
22	8470	.24540	8211	.25094	7956	.25659	7707	.26234	7462	.26820	8
	8466	.24550	8207	.25104	7952	.25668	7702	.26244	7458	.26830	
23	8461	.24559	8202	.25113	7948	.25678	7698	.26253	7453	.26840	7
	8457	.24568	8198	.25122	7944	.25687	7694	.26263	7449	.26850	
24	8453	.24577	8194	.25132	7940	.25697	7690	.26273	7445	.26860	6
	8448	.24586	8189	.25141	7935	.25706	7686	.26282	7441	.26869	
25	8444	.24595	8185	.25150	7931	.25716	7682	.26292	7437	.26879	5
	8440	.24605	8181	.25160	7927	.25725	7678	.26302	7433	.26889	
26	8435	.24614	8177	.25169	7923	.25735	7674	.26311	7429	.26899	4
	8431	.24623	8172	.25178	7919	.25744	7670	.26321	7425	.26909	
27	8427	.24632	8168	.25188	7914	.25754	7665	.26331	7421	.26919	3
	8422	.24641	8164	.25197	7910	.25763	7661	.26340	7417	.26929	
28	8418	.24650	8160	.25206	7906	.25773	7657	.26350	7413	.26939	2
	8414	.24660	8155	.25216	7902	.25782	7653	.26360	7409	.26949	
29	8409	.24669	8151	.25225	7898	.25792	7649	.26370	7405	.26958	1
	8405	.24678	8147	.25234	7893	.25801	7645	.26379	7401	.26968	
30	8401	.24687	8143	.25244	7889	.25811	7641	.26389	7397	.26978	0
'	A	B	A	B	A	B	A	B	A	B	'
	124°30'		124°00'		123°30'		123°00'		122°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	57°30'		58°00'		58°30'		59°00'		59°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	7397	.26978	7158	.27579	6923	.28191	6693	.28816	6468	.29453	30
	7393	.26988	7154	.27589	6920	.28202	6690	.28827	6464	.29464	
1	7389	.26998	7150	.27599	6916	.28212	6686	.28837	6460	.29475	29
	7385	.27008	7146	.27609	6912	.28222	6682	.28848	6457	.29485	
2	7381	.27018	7142	.27619	6908	.28233	6678	.28858	6453	.29496	28
	7377	.27028	7138	.27630	6904	.28243	6674	.28869	6449	.29507	
3	7373	.27038	7134	.27640	6900	.28253	6671	.28879	6446	.29517	27
	7369	.27048	7130	.27650	6896	.28264	6667	.28890	6442	.29528	
4	7365	.27058	7126	.27660	6892	.28274	6663	.28900	6438	.29539	26
	7361	.27068	7122	.27670	6889	.28284	6659	.28911	6434	.29550	
5	7357	.27078	7118	.27680	6885	.28295	6655	.28921	6431	.29560	25
	7353	.27088	7115	.27690	6881	.28305	6652	.28932	6427	.29571	
6	7349	.27098	7111	.27701	6877	.28315	6648	.28942	6423	.29582	24
	7345	.27107	7107	.27711	6873	.28326	6644	.28953	6420	.29593	
7	7341	.27117	7103	.27721	6869	.28336	6640	.28964	6416	.29604	23
	7337	.27127	7099	.27731	6865	.28346	6637	.28974	6412	.29614	
8	7333	.27137	7095	.27741	6862	.28357	6633	.28985	6409	.29625	22
	7329	.27147	7091	.27751	6858	.28367	6629	.28995	6405	.29636	
9	7325	.27157	7087	.27761	6854	.28378	6625	.29006	6401	.29647	21
	7321	.27167	7083	.27772	6850	.28388	6622	.29016	6397	.29657	
10	7317	.27177	7079	.27782	6846	.28398	6618	.29027	6394	.29668	20
	7313	.27187	7075	.27792	6842	.28409	6614	.29038	6390	.29679	
11	7309	.27197	7071	.27802	6839	.28419	6610	.29048	6386	.29690	19
	7305	.27207	7068	.27812	6835	.28429	6607	.29059	6383	.29701	
12	7301	.27217	7064	.27823	6831	.28440	6603	.29069	6379	.29711	18
	7297	.27227	7060	.27833	6827	.28450	6599	.29080	6375	.29722	
13	7293	.27237	7056	.27843	6823	.28461	6595	.29091	6372	.29733	17
	7289	.27247	7052	.27853	6819	.28471	6591	.29101	6368	.29744	
14	7285	.27257	7048	.27863	6815	.28481	6588	.29112	6364	.29755	16
	7281	.27267	7044	.27874	6812	.28492	6584	.29122	6361	.29766	
15	7277	.27277	7040	.27884	6808	.28502	6580	.29133	6357	.29776	15
	7273	.27287	7036	.27894	6804	.28513	6576	.29144	6353	.29787	
16	7269	.27297	7032	.27904	6800	.28523	6573	.29154	6349	.29798	14
	7265	.27307	7028	.27914	6796	.28533	6569	.29165	6346	.29809	
17	7261	.27317	7024	.27925	6792	.28544	6565	.29175	6342	.29820	13
	7257	.27327	7021	.27935	6789	.28554	6561	.29186	6338	.29831	
18	7253	.27337	7017	.27945	6785	.28565	6558	.29197	6335	.29841	12
	7249	.27347	7013	.27955	6781	.28575	6554	.29207	6331	.29852	
19	7245	.27357	7009	.27965	6777	.28586	6550	.29218	6327	.29863	11
	7241	.27367	7005	.27976	6773	.28596	6546	.29229	6324	.29874	
20	7237	.27377	7001	.27986	6770	.28607	6543	.29239	6320	.29885	10
	7233	.27387	6997	.27996	6766	.28617	6539	.29250	6316	.29896	
21	7229	.27398	6993	.28006	6762	.28627	6535	.29261	6313	.29907	9
	7225	.27408	6989	.28017	6758	.28638	6531	.29271	6309	.29917	
22	7221	.27418	6985	.28027	6754	.28648	6528	.29282	6305	.29929	8
	7217	.27428	6982	.28037	6750	.28659	6524	.29293	6302	.29939	
23	7213	.27438	6978	.28047	6747	.28669	6520	.29303	6298	.29950	7
	7209	.27448	6974	.28058	6743	.28680	6516	.29314	6294	.29961	
24	7205	.27458	6970	.28068	6739	.28690	6513	.29325	6291	.29972	6
	7201	.27468	6966	.28078	6735	.28701	6509	.29335	6287	.29983	
25	7197	.27478	6962	.28089	6731	.28711	6505	.29346	6283	.29994	5
	7193	.27488	6958	.28099	6728	.28722	6502	.29357	6280	.30005	
26	7190	.27498	6954	.28109	6724	.28732	6498	.29367	6276	.30015	4
	7186	.27508	6951	.28119	6720	.28743	6494	.29378	6272	.30026	
27	7182	.27518	6947	.28130	6716	.28753	6490	.29389	6269	.30037	3
	7178	.27528	6943	.28140	6712	.28763	6487	.29399	6265	.30048	
28	7174	.27539	6939	.28150	6709	.28774	6483	.29410	6261	.30059	2
	7170	.27549	6935	.28161	6705	.28784	6479	.29421	6258	.30070	
29	7166	.27559	6931	.28171	6701	.28795	6475	.29432	6254	.30081	1
	7162	.27569	6927	.28181	6697	.28806	6472	.29442	6251	.30092	
30	7158	.27579	6923	.28191	6693	.28816	6468	.29453	6247	.30103	0
'	A	B	A	B	A	B	A	B	A	B	'
	122°00'		121°30'		121°00'		120°30'		120°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	60°00' A	60°00' B	60°30' A	60°30' B	61°00' A	61°00' B	61°30' A	61°30' B	62°00' A	62°00' B	'
0	6247	30103	6030	30766	5818	31443	5610	32134	5406	32839	30
	6243	30114	6027	30777	5815	31454	5607	32145	5403	32851	
1	6240	30125	6023	30788	5811	31466	5603	32157	5400	32863	29
	6236	30136	6020	30800	5808	31477	5600	32169	5396	32875	
2	6232	30147	6016	30811	5804	31488	5596	32180	5393	32887	28
	6229	30158	6012	30822	5801	31500	5593	32192	5390	32898	
3	6225	30169	6009	30833	5797	31511	5590	32204	5386	32910	27
	6221	30180	6005	30844	5794	31523	5586	32215	5383	32922	
4	6218	30191	6002	30856	5790	31534	5583	32227	5380	32934	26
	6214	30202	5998	30867	5787	31546	5579	32239	5376	32946	
5	6210	30213	5995	30878	5783	31557	5575	32250	5373	32958	25
	6207	30224	5991	30889	5780	31569	5572	32262	5370	32970	
6	6203	30235	5987	30900	5776	31580	5569	32274	5366	32982	24
	6200	30245	5984	30912	5773	31591	5566	32285	5363	32994	
7	6196	30256	5980	30923	5769	31603	5562	32297	5360	33006	23
	6192	30267	5977	30934	5766	31614	5559	32309	5356	33018	
8	6189	30278	5973	30945	5762	31626	5555	32320	5353	33030	22
	6185	30289	5970	30956	5759	31637	5552	32332	5350	33042	
9	6181	30300	5966	30968	5755	31649	5549	32344	5346	33054	21
	6178	30311	5963	30979	5752	31660	5545	32355	5343	33065	
10	6174	30322	5959	30990	5748	31672	5542	32367	5340	33077	20
	6171	30334	5955	31001	5745	31683	5538	32379	5336	33089	
11	6167	30345	5952	31013	5741	31694	5535	32391	5333	33101	19
	6163	30355	5948	31024	5738	31706	5532	32402	5330	33113	
12	6160	30367	5945	31035	5734	31717	5528	32414	5326	33125	18
	6156	30378	5941	31046	5731	31729	5525	32426	5323	33137	
13	6152	30389	5938	31058	5727	31740	5521	32438	5320	33149	17
	6149	30400	5934	31069	5724	31752	5518	32449	5316	33161	
14	6145	30411	5931	31080	5720	31763	5515	32461	5313	33173	16
	6142	30422	5927	31091	5717	31775	5511	32473	5310	33185	
15	6138	30433	5924	31103	5714	31786	5508	32484	5306	33197	15
	6134	30444	5920	31114	5710	31798	5504	32496	5303	33209	
16	6131	30455	5917	31125	5707	31809	5501	32508	5300	33221	14
	6127	30466	5913	31137	5703	31821	5498	32520	5296	33233	
17	6124	30477	5909	31148	5700	31833	5494	32532	5293	33245	13
	6120	30488	5906	31159	5696	31844	5491	32543	5290	33257	
18	6116	30499	5902	31170	5693	31856	5487	32555	5286	33269	12
	6113	30510	5899	31182	5689	31867	5484	32567	5283	33281	
19	6109	30521	5895	31193	5686	31879	5481	32579	5280	33293	11
	6106	30532	5892	31204	5682	31890	5477	32590	5276	33306	
20	6102	30544	5888	31216	5679	31902	5474	32602	5273	33318	10
	6098	30555	5885	31227	5675	31913	5470	32614	5270	33330	
21	6095	30566	5881	31238	5672	31925	5467	32625	5266	33342	9
	6091	30577	5878	31250	5669	31936	5464	32638	5263	33354	
22	6088	30588	5874	31261	5665	31948	5460	32649	5260	33366	8
	6084	30599	5871	31272	5662	31960	5457	32661	5257	33378	
23	6080	30610	5867	31284	5658	31971	5454	32673	5253	33390	7
	6077	30621	5864	31295	5655	31983	5450	32685	5250	33402	
24	6073	30632	5860	31306	5651	31994	5447	32697	5247	33414	6
	6070	30643	5857	31318	5648	32006	5443	32709	5243	33426	
25	6066	30655	5853	31329	5644	32018	5440	32720	5240	33438	5
	6062	30666	5850	31340	5641	32029	5437	32732	5237	33450	
26	6059	30677	5846	31352	5638	32041	5433	32744	5233	33462	4
	6055	30688	5843	31363	5634	32052	5430	32756	5230	33475	
27	6052	30699	5839	31375	5631	32064	5427	32768	5227	33487	3
	6048	30710	5836	31386	5627	32076	5423	32780	5224	33499	
28	6045	30721	5832	31397	5624	32087	5420	32792	5220	33511	2
	6041	30733	5829	31409	5620	32099	5417	32803	5217	33523	
29	6037	30744	5825	31420	5617	32110	5413	32815	5214	33535	1
	6034	30755	5822	31431	5614	32122	5410	32827	5210	33547	
30	6030	30766	5818	31443	5610	32134	5406	32839	5207	33559	0
'	A	B	A	B	A	B	A	B	A	B	'
	119°30'		119°00'		118°30'		118°00'		117°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE.

'	62°30'		63°00'		63°30'		64°00'		64°30'		'
'	A	B	A	B	A	B	A	B	A	B	'
0	5207	.33559	5012	.34295	4821	.35047	4634	.35816	4451	.36602	30
	5204	.33572	5009	.34308	4818	.35060	4631	.35829	4448	.36615	
1	5200	.33584	5005	.34320	4815	.35073	4628	.35842	4445	.36628	29
	5197	.33596	5002	.34332	4811	.35085	4625	.35855	4442	.36641	
2	5194	.33608	4999	.34345	4808	.35098	4622	.35868	4439	.36655	28
	5191	.33620	4996	.34357	4805	.35111	4619	.35881	4436	.36668	
3	5187	.33632	4993	.34370	4802	.35123	4615	.35894	4433	.36681	27
	5184	.33644	4989	.34382	4799	.35136	4612	.35907	4430	.36694	
4	5181	.33657	4986	.34395	4796	.35149	4609	.35920	4427	.36708	26
	5178	.33669	4983	.34407	4793	.35161	4606	.35933	4424	.36721	
5	5174	.33681	4980	.34420	4789	.35174	4603	.35946	4421	.36734	25
	5171	.33693	4977	.34432	4786	.35187	4600	.35959	4418	.36747	
6	5168	.33705	4973	.34444	4783	.35200	4597	.35972	4415	.36761	24
	5164	.33717	4970	.34457	4780	.35212	4594	.35985	4412	.36774	
7	5161	.33730	4967	.34469	4777	.35225	4591	.35998	4409	.36787	23
	5158	.33742	4964	.34482	4774	.35238	4588	.36011	4406	.36801	
8	5155	.33754	4961	.34494	4771	.35251	4585	.36024	4403	.36814	22
	5155	.33766	4957	.34507	4767	.35263	4582	.36037	4400	.36827	
9	5148	.33779	4954	.34519	4764	.35276	4579	.36050	4397	.36841	21
	5145	.33791	4951	.34532	4761	.35289	4576	.36063	4394	.36854	
10	5142	.33803	4948	.34544	4758	.35302	4573	.36076	4391	.36867	20
	5138	.33815	4945	.34557	4755	.35314	4569	.36089	4388	.36881	
11	5135	.33827	4941	.34569	4752	.35327	4566	.36102	4385	.36894	19
	5132	.33840	4938	.34582	4749	.35340	4563	.36115	4382	.36907	
12	5128	.33852	4935	.34594	4746	.35353	4560	.36128	4379	.36921	18
	5125	.33864	4932	.34607	4742	.35365	4557	.36141	4376	.36934	
13	5122	.33876	4929	.34619	4739	.35378	4554	.36154	4373	.36948	17
	5119	.33889	4925	.34632	4736	.35391	4551	.36167	4370	.36961	
14	5115	.33901	4922	.34644	4733	.35404	4548	.36180	4367	.36974	16
	5112	.33913	4919	.34657	4730	.35417	4545	.36193	4364	.36988	
15	5109	.33925	4916	.34669	4727	.35429	4542	.36206	4361	.37001	15
	5106	.33938	4913	.34682	4724	.35442	4529	.36220	4358	.37014	
16	5102	.33950	4910	.34694	4721	.35455	4536	.36233	4355	.37028	14
	5099	.33962	4906	.34707	4718	.35468	4533	.36246	4352	.37041	
17	5096	.33974	4903	.34719	4714	.35481	4530	.36259	4349	.37055	13
	5093	.33987	4900	.34732	4711	.35493	4527	.36272	4346	.37068	
18	5089	.33999	4897	.34744	4708	.35506	4524	.36285	4343	.37081	12
	5086	.34011	4894	.34757	4705	.35519	4521	.36298	4340	.37095	
19	5083	.34024	4890	.34770	4702	.35532	4518	.36311	4337	.37108	11
	5080	.34036	4887	.34782	4699	.35545	4515	.36325	4334	.37122	
20	5076	.34048	4884	.34795	4696	.35558	4512	.36338	4332	.37135	10
	5073	.34061	4881	.34807	4693	.35571	4509	.36351	4329	.37149	
21	5070	.34073	4878	.34820	4690	.35583	4506	.36364	4326	.37162	9
	5067	.34085	4875	.34832	4686	.35596	4503	.36377	4323	.37176	
22	5064	.34097	4871	.34845	4683	.35609	4500	.36390	4320	.37189	8
	5060	.34110	4868	.34858	4680	.35622	4497	.36403	4317	.37203	
23	5057	.34122	4865	.34870	4677	.35635	4493	.36417	4314	.37216	7
	5054	.34134	4862	.34883	4674	.35648	4490	.36430	4311	.37229	
24	5051	.34147	4859	.34896	4671	.35661	4487	.36443	4308	.37243	6
	5047	.34159	4856	.34908	4668	.35674	4484	.36456	4305	.37256	
25	5044	.34172	4852	.34921	4665	.35686	4481	.36469	4302	.37270	5
	5041	.34184	4849	.34933	4662	.35699	4478	.36483	4299	.37283	
26	5038	.34196	4846	.34946	4659	.35712	4475	.36496	4296	.37297	4
	5034	.34209	4843	.34959	4656	.35725	4472	.36509	4293	.37310	
27	5031	.34221	4840	.34971	4652	.35738	4469	.36522	4290	.37324	3
	5028	.34233	4837	.34984	4649	.35751	4466	.36535	4287	.37337	
28	5025	.34246	4833	.34997	4646	.35764	4463	.36549	4284	.37351	2
	5022	.34258	4830	.35009	4643	.35777	4469	.36562	4281	.37365	
29	5018	.34270	4827	.35022	4640	.35790	4457	.36575	4278	.37378	1
	5015	.34283	4824	.35035	4637	.35803	4454	.36588	4275	.37392	
30	5012	.34295	4821	.35047	4634	.35816	4451	.36602	4272	.37405	0
'	A	B	A	B	A	B	A	B	A	B	'
	117°00'		116°30'		116°00'		115°30'		115°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

'	65°00' A	65°00' B	65°30' A	65°30' B	66°00' A	66°00' B	66°30' A	66°30' B	67°00' A	67°00' B	'
0	4272	.37405	4098	.38227	3927	.39069	3760	.39930	3597	.40812	30
	4269	.37419	4095	.38241	3924	.39083	3757	.39945	3595	.40827	
1	4266	.37432	4092	.38255	3921	.39097	3755	.39959	3592	.40842	29
	4264	.37446	4089	.38269	3918	.39111	3752	.39974	3589	.40857	
2	4261	.37459	4086	.38283	3916	.39125	3749	.39988	3587	.40872	28
	4258	.37473	4083	.38297	3913	.39140	3746	.40003	3584	.40887	
3	4255	.37487	4080	.38311	3910	.39154	3744	.40017	3581	.40902	27
	4252	.37500	4078	.38324	3907	.39168	3741	.40032	3579	.40916	
4	4249	.37514	4075	.38338	3904	.39182	3738	.40046	3576	.40931	26
	4246	.37527	4072	.38352	3902	.39197	3735	.40061	3573	.40946	
5	4243	.37541	4069	.38366	3899	.39211	3733	.40076	3571	.40961	25
	4240	.37554	4066	.38380	3896	.39225	3730	.40090	3568	.40976	
6	4237	.37568	4063	.38394	3893	.39239	3727	.40105	3565	.40991	24
	4234	.37582	4060	.38408	3890	.39254	3725	.40119	3563	.41006	
7	4231	.37595	4057	.38422	3888	.39268	3722	.40134	3560	.41021	23
	4228	.37609	3055	.38436	3885	.39282	3719	.40149	3557	.41036	
8	4225	.37623	4052	.38450	3882	.39296	3716	.40163	3555	.41051	22
	4222	.37636	4049	.38464	3879	.39311	3714	.40178	3552	.41066	
9	4220	.37650	4046	.38478	3876	.39325	3711	.40192	3549	.41081	21
	4217	.37663	4043	.38492	3874	.39339	3708	.40207	3547	.41096	
10	4214	.37677	4040	.38506	3871	.39353	3705	.40222	3544	.41111	20
	4211	.37691	4037	.38520	3868	.39368	3703	.40236	3541	.41126	
11	4208	.37704	4035	.38533	3865	.39382	3700	.40251	3539	.41141	19
	4205	.37718	4032	.38547	3863	.39396	3697	.40266	3536	.41156	
12	4202	.37732	4029	.38561	3860	.39411	3695	.40280	3533	.41171	18
	4199	.37745	4026	.38575	3857	.39425	3692	.40295	3531	.41186	
13	4196	.37759	4023	.38589	3854	.39439	3689	.40310	3528	.41201	17
	4193	.37773	4020	.38603	3851	.39454	3686	.40324	3525	.41216	
14	4190	.37786	4017	.38617	3849	.39468	3684	.40339	3523	.41231	16
	4187	.37800	4015	.38631	3846	.39482	3681	.40354	3520	.41246	
15	4185	.37814	4012	.38645	3843	.39497	3678	.40368	3517	.41261	15
	4182	.37828	4009	.38660	3840	.39511	3676	.40383	3515	.41276	
16	4179	.37841	4006	.38674	3838	.39525	3673	.40398	3512	.41291	14
	4176	.37855	4003	.38688	3835	.39540	3670	.40413	3509	.41307	
17	4173	.37869	4000	.38702	3832	.39554	3667	.40427	3507	.41322	13
	4170	.37882	3998	.38716	3829	.39569	3665	.40442	3504	.41337	
18	4167	.37896	3995	.38730	3826	.39583	3662	.40457	3502	.41352	12
	4164	.37910	3992	.38744	3824	.39597	3659	.40471	3499	.41367	
19	4161	.37924	3989	.38758	3821	.39612	3657	.40486	3496	.41382	11
	4158	.37937	3986	.38772	3818	.39626	3654	.40501	3494	.41397	
20	4155	.37951	3983	.38786	3815	.39641	3651	.40516	3491	.41412	10
	4153	.37965	3981	.38800	3813	.39655	3648	.40530	3488	.41427	
21	4150	.37979	3978	.38814	3810	.39669	3646	.40545	3486	.41443	9
	4147	.37992	3975	.38828	3807	.39684	3643	.40560	3483	.41458	
22	4144	.38006	3972	.38842	3804	.39698	3640	.40575	3480	.41473	8
	4141	.38020	3969	.38856	3801	.39713	3638	.40590	3478	.41488	
23	4138	.38034	3966	.38871	3799	.39727	3635	.40604	3475	.41503	7
	4135	.38048	3964	.38885	3796	.39742	3632	.40619	3473	.41518	
24	4132	.38061	3961	.38899	3793	.39756	3630	.40634	3470	.41533	6
	4129	.38075	3958	.38913	3790	.39771	3627	.40649	3467	.41549	
25	4127	.38089	3955	.38927	3788	.39785	3624	.40664	3465	.41564	5
	4124	.38103	3952	.38941	3785	.39799	3622	.40678	3462	.41579	
26	4121	.38117	3949	.38955	3782	.39814	3619	.40693	3459	.41594	4
	4118	.38130	3947	.38969	3779	.39828	3616	.40708	3457	.41609	
27	4115	.38144	3944	.38984	3777	.39843	3613	.40723	3454	.41625	3
	4112	.38158	3941	.38998	3774	.39857	3611	.40738	3452	.41640	
28	4109	.38172	3938	.39012	3771	.39872	3608	.40753	3449	.41655	2
	4106	.38186	3935	.39026	3768	.39886	3605	.40768	3446	.41670	
29	4103	.38200	3933	.39040	3766	.39901	3603	.40782	3444	.41685	1
	4101	.38213	3930	.39054	3763	.39915	3600	.40797	3441	.41701	
30	4098	.38227	3927	.39069	3760	.39930	3597	.40812	3438	.41716	0
'	A	B	A	B	A	B	A	B	A	B	'
	114°30'		114°00'		113°30'		113°00'		112°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	67°30'		68°00'		68°30'		69°00'		69°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	3438	.41716	3283	.42642	3132	.43592	2985	.44567	2841	.45567	30
	3436	.41731	3281	.42658	3130	.43608	2982	.44583	2839	.45584	
1	3433	.41746	3278	.42674	3127	.43624	2980	.44600	2836	.45601	29
	3431	.41762	3276	.42689	3125	.43641	2978	.44616	2834	.45618	
2	3428	.41777	3273	.42705	3122	.43657	2975	.44633	2832	.45635	28
	3425	.41792	3271	.42721	3120	.43673	2973	.44649	2829	.45652	
3	3423	.41808	3268	.42736	3117	.43689	2970	.44666	2827	.45669	27
	3420	.41823	3266	.42752	3115	.43705	2968	.44682	2825	.45686	
4	3418	.41838	3263	.42768	3112	.43721	2965	.44699	2822	.45703	26
	3415	.41853	3260	.42783	3110	.43737	2963	.44715	2820	.45720	
5	3412	.41869	3258	.42799	3107	.43753	2961	.44732	2818	.45737	25
	3410	.41884	3255	.42815	3105	.43769	2958	.44748	2815	.45754	
6	3407	.41899	3253	.42830	3102	.43785	2956	.44765	2813	.45771	24
	3404	.41915	3250	.42846	3100	.43801	2953	.44782	2811	.45788	
7	3402	.41930	3248	.42862	3097	.43818	2951	.44798	2808	.45805	23
	3399	.41945	3245	.42878	3095	.43834	2949	.44815	2806	.45822	
8	3397	.41961	3243	.42893	3092	.43850	2946	.44831	2804	.45839	22
	3394	.41976	3240	.42909	3090	.43866	2944	.44848	2801	.45856	
9	3391	.41991	3237	.42925	3088	.43882	2941	.44864	2799	.45873	21
	3389	.42007	3235	.42941	3085	.43898	2939	.44881	2797	.45890	
10	3386	.42022	3233	.42956	3083	.43914	2936	.44898	2794	.45907	20
	3384	.42038	3230	.42972	3080	.43931	2934	.44914	2792	.45924	
11	3381	.42053	3227	.42988	3078	.43947	2932	.44931	2789	.45941	19
	3379	.42068	3225	.43004	3075	.43963	2929	.44947	2787	.45958	
12	3376	.42084	3222	.43020	3073	.43979	2927	.44964	2785	.45975	18
	3373	.42099	3220	.43035	3070	.43995	2924	.44981	2782	.45992	
13	3371	.42115	3217	.43051	3068	.44012	2922	.44997	2780	.46009	17
	3368	.42130	3215	.43067	3065	.44028	2920	.45014	2778	.46026	
14	3366	.42145	3212	.43083	3063	.44044	2917	.45031	2775	.46043	16
	3363	.42161	3210	.43099	3060	.44060	2915	.45047	2773	.46061	
15	3360	.42176	3207	.43114	3058	.44077	2913	.45064	2771	.46078	15
	3358	.42192	3205	.43130	3056	.44093	2910	.45081	2768	.46095	
16	3355	.42207	3202	.43146	3053	.44109	2908	.45097	2766	.46112	14
	3353	.42223	3200	.43162	3051	.44125	2905	.45114	2764	.46129	
17	3350	.42238	3197	.43178	3048	.44142	2903	.45131	2761	.46146	13
	3348	.42254	3195	.43194	3046	.44158	2901	.45147	2759	.46163	
18	3345	.42269	3192	.43210	3043	.44174	2898	.45164	2757	.46181	12
	3342	.42285	3190	.43225	3041	.44190	2896	.45181	2755	.46198	
19	3340	.42300	3187	.43241	3038	.44207	2893	.45198	2752	.46215	11
	3337	.42316	3185	.43257	3036	.44223	2891	.45214	2750	.46232	
20	3335	.42331	3182	.43273	3033	.44239	2889	.45231	2748	.46249	10
	3332	.42347	3180	.43289	3031	.44256	2886	.45248	2745	.46266	
21	3329	.42362	3177	.43305	3029	.44272	2884	.45265	2743	.46284	9
	3327	.42378	3175	.43321	3026	.44288	2881	.45281	2741	.46301	
22	3324	.42393	3172	.43337	3024	.44305	2879	.45298	2738	.46318	8
	3322	.42409	3170	.43353	3021	.44321	2877	.45315	2736	.46335	
23	3319	.42424	3167	.43369	3019	.44337	2874	.45332	2734	.46353	7
	3317	.42440	3165	.43385	3016	.44354	2872	.45348	2731	.46370	
24	3314	.42455	3162	.43400	3014	.44370	2870	.45365	2729	.46387	6
	3312	.42471	3160	.43416	3012	.44386	2867	.45382	2727	.46404	
25	3309	.42486	3157	.43432	3009	.44403	2865	.45399	2724	.46422	5
	3306	.42502	3155	.43448	3007	.44419	2862	.45416	2722	.46439	
26	3304	.42518	3152	.43464	3004	.44436	2860	.45433	2720	.46456	4
	3301	.42533	3150	.43480	3002	.44452	2858	.45449	2717	.46473	
27	3299	.42549	3147	.43496	2999	.44468	2855	.45466	2715	.46491	3
	3296	.42564	3145	.43512	2997	.44485	2853	.45483	2713	.46508	
28	3294	.42580	3142	.43528	2994	.44501	2851	.45500	2711	.46525	2
	3291	.42596	3140	.43544	2992	.44518	2848	.45517	2708	.46543	
29	3289	.42611	3137	.43560	2990	.44534	2846	.45534	2706	.46560	1
	3286	.42627	3135	.43576	2987	.44551	2844	.45551	2704	.46577	
30	3283	.42642	3132	.43592	2985	.44567	2841	.45567	2701	.46595	0
'	A	B	A	B	A	B	A	B	A	B	'
	112°00'		111°30'		111°00'		110°30'		110°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	70°00'		70°30'		71°00'		71°30'		72°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	2701	.46595	2565	.47650	2433	.48736	2304	.49852	2179	.51002	30
	2699	.46612	2563	.47668	2431	.48754	2302	.49871	2177	.51021	
1	2697	.46630	2561	.47686	2429	.48772	2300	.49890	2175	.51041	29
	2694	.46647	2559	.47704	2427	.48791	2298	.49909	2173	.51060	
2	2692	.46664	2556	.47722	2424	.48809	2296	.49928	2171	.51080	28
	2690	.46682	2554	.47740	2422	.48828	2294	.49947	2169	.51099	
3	2688	.46699	2552	.47758	2420	.48846	2292	.49966	2167	.51119	27
	2685	.46716	2550	.47775	2418	.48864	2290	.49985	2165	.51138	
4	2683	.46734	2547	.47793	2416	.48883	2287	.50004	2163	.51158	26
	2681	.46751	2545	.47811	2413	.48901	2285	.50023	2161	.51177	
5	2678	.46769	2543	.47829	2411	.48920	2283	.50042	2159	.51197	25
	2676	.46786	2541	.47847	2409	.48938	2281	.50061	2157	.51216	
6	2674	.46804	2539	.47865	2407	.48957	2279	.50080	2155	.51236	24
	2672	.46821	2536	.47883	2405	.48975	2277	.50098	2153	.51255	
7	2669	.46839	2534	.47901	2403	.48993	2275	.50117	2151	.51275	23
	2667	.46856	2532	.47919	2400	.49012	2273	.50137	2149	.51294	
8	2665	.46873	2530	.47937	2398	.49030	2271	.50156	2147	.51314	22
	2662	.46891	2528	.47955	2396	.49049	2269	.50175	2145	.51334	
9	2660	.46908	2525	.47973	2394	.49067	2266	.50194	2143	.51353	21
	2658	.46926	2523	.47991	2392	.49086	2264	.50213	2141	.51373	
10	2656	.46943	2521	.48009	2390	.49104	2262	.50232	2138	.51392	20
	2653	.46961	2519	.48027	2387	.49123	2260	.50251	2136	.51412	
11	2651	.46978	2516	.48045	2385	.49141	2258	.50270	2134	.51432	19
	2649	.46996	2514	.48063	2383	.49160	2256	.50289	2132	.51451	
12	2646	.47014	2512	.48081	2381	.49179	2254	.50308	2130	.51471	18
	2644	.47031	2510	.48099	2379	.49197	2252	.50327	2128	.51491	
13	2642	.47049	2507	.48117	2377	.49216	2250	.50346	2126	.51510	17
	2640	.47066	2505	.48135	2375	.49234	2248	.50365	2124	.51530	
14	2637	.47084	2503	.48153	2372	.49253	2246	.50385	2122	.51550	16
	2635	.47101	2501	.48171	2370	.49271	2243	.50404	2120	.51570	
15	2633	.47119	2499	.48189	2368	.49290	2241	.50423	2118	.51589	15
	2631	.47137	2496	.48207	2366	.49309	2239	.50442	2116	.51609	
16	2628	.47154	2494	.48226	2364	.49327	2237	.50461	2114	.51629	14
	2626	.47172	2492	.48244	2362	.49346	2235	.50480	2112	.51649	
17	2624	.47189	2490	.48262	2360	.49365	2233	.50499	2110	.51668	13
	2622	.47207	2488	.48280	2358	.49383	2231	.50519	2108	.51688	
18	2619	.47225	2485	.48298	2355	.49402	2229	.50538	2106	.51708	12
	2617	.47242	2483	.48316	2353	.49421	2227	.50557	2104	.51728	
19	2615	.47269	2481	.48334	2351	.49439	2225	.50576	2102	.51747	11
	2613	.47278	2479	.48352	2349	.49458	2223	.50596	2100	.51767	
20	2610	.47295	2477	.48371	2347	.49477	2221	.50615	2098	.51787	10
	2608	.47313	2474	.48389	2345	.49495	2218	.50634	2096	.51807	
21	2606	.47331	2472	.48407	2343	.49514	2216	.50653	2094	.51827	9
	2604	.47348	2470	.48425	2340	.49533	2214	.50673	2092	.51847	
22	2601	.47366	2468	.48443	2338	.49551	2212	.50692	2090	.51867	8
	2599	.47384	2466	.48462	2336	.49570	2210	.50711	2088	.51886	
23	2597	.47402	2463	.48480	2334	.49589	2208	.50730	2086	.51906	7
	2594	.47419	2461	.48498	2332	.49608	2206	.50750	2084	.51926	
24	2592	.47437	2459	.48516	2330	.49626	2204	.50769	2082	.51946	6
	2590	.47455	2457	.48534	2328	.49645	2202	.50788	2080	.51966	
25	2588	.47472	2455	.48553	2325	.49664	2200	.50808	2078	.51986	5
	2585	.47490	2453	.48571	2323	.49683	2198	.50827	2076	.52006	
26	2583	.47508	2450	.48589	2321	.49702	2196	.50846	2074	.52026	4
	2581	.47526	2448	.48608	2319	.49720	2194	.50866	2072	.52046	
27	2579	.47544	2446	.48626	2317	.49739	2192	.50885	2070	.52066	3
	2576	.47561	2444	.48644	2315	.49758	2190	.50905	2068	.52086	
28	2574	.47579	2442	.48662	2313	.49777	2188	.50924	2066	.52106	2
	2572	.47597	2439	.48681	2311	.49796	2185	.50943	2064	.52126	
29	2570	.47615	2437	.48699	2309	.49815	2183	.50963	2062	.52146	1
	2568	.47633	2435	.48717	2306	.49833	2181	.50982	2060	.52166	
30	2565	.47650	2433	.48736	2304	.49852	2179	.51002	2058	.52186	0
'	A	B	A	B	A	B	A	B	A	B	'
	109°30'		109°00'		108°30'		108°00'		107°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	72°30'		73°00'		73°30'		74°00'		74°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	2058	.52186	1940	.53406	1826	.54666	1716	.55966	1609	.57310	30
	2056	.52206	1938	.53427	1824	.54687	1714	.55988	1607	.57333	
1	2054	.52226	1936	.53448	1823	.54708	1712	.56010	1605	.57356	29
	2052	.52246	1935	.53468	1821	.54730	1710	.56032	1604	.57378	
2	2050	.52266	1933	.52489	1819	.54751	1709	.56054	1602	.57401	28
	2048	.52286	1931	.53510	1817	.54773	1707	.56076	1600	.57424	
3	2046	.52306	1929	.53531	1815	.54794	1705	.56099	1598	.57447	27
	2044	.52326	1927	.53551	1813	.54815	1703	.56121	1597	.57470	
4	2042	.52346	1925	.53572	1811	.54837	1701	.56143	1595	.57493	26
	2040	.52366	1923	.53593	1809	.54858	1700	.56165	1593	.57516	
5	2038	.52387	1921	.53614	1808	.54880	1698	.56187	1591	.57538	25
	2036	.52407	1919	.53634	1806	.54901	1696	.56209	1590	.57561	
6	2034	.52427	1917	.53655	1804	.54922	1694	.56231	1588	.57584	24
	2032	.52447	1915	.53676	1802	.54944	1692	.56254	1586	.57607	
7	2030	.52467	1913	.53697	1800	.54965	1691	.56276	1584	.57630	23
	2028	.52487	1911	.53718	1798	.54987	1689	.56298	1583	.57653	
8	2026	.52508	1910	.53738	1796	.55008	1687	.56320	1581	.57676	22
	2024	.52528	1908	.53759	1795	.55030	1685	.56342	1579	.57699	
9	2022	.52548	1906	.53780	1793	.55051	1683	.56365	1578	.57722	21
	2020	.52568	1904	.53801	1791	.55073	1682	.56387	1576	.57745	
10	2018	.52588	1902	.53822	1789	.55095	1680	.56409	1574	.57768	20
	2016	.52609	1900	.53843	1787	.55116	1678	.56431	1572	.57791	
11	2014	.52629	1898	.53864	1785	.55138	1676	.56454	1571	.57814	19
	2012	.52649	1896	.53884	1783	.55159	1674	.56476	1569	.57837	
12	2010	.52670	1894	.53905	1782	.55181	1673	.56498	1567	.57860	18
	2009	.52690	1892	.53926	1780	.55202	1671	.56521	1565	.57884	
13	2007	.52710	1890	.53947	1778	.55224	1669	.56543	1564	.57907	17
	2005	.52730	1889	.53968	1776	.55246	1667	.56565	1562	.57930	
14	2003	.52751	1887	.53989	1774	.55267	1665	.56588	1560	.57953	16
	2001	.52771	1885	.54010	1772	.55289	1664	.56610	1559	.57976	
15	1999	.52791	1883	.54031	1771	.55311	1662	.56632	1557	.57999	15
	1997	.52812	1881	.54052	1769	.55332	1660	.56655	1555	.58022	
16	1995	.52832	1879	.54073	1767	.55354	1658	.56677	1553	.58046	14
	1993	.52852	1877	.54094	1765	.55376	1657	.56700	1552	.58069	
17	1991	.52873	1875	.54115	1763	.55397	1655	.56722	1550	.58092	13
	1989	.52893	1873	.54136	1761	.55419	1653	.56745	1548	.58115	
18	1987	.52914	1871	.54157	1760	.55441	1651	.56767	1546	.58138	12
	1985	.52934	1870	.54178	1758	.55463	1650	.56790	1545	.58162	
19	1983	.52954	1868	.54199	1756	.55484	1648	.56812	1543	.58185	11
	1981	.52975	1866	.54220	1754	.55506	1646	.56835	1541	.58208	
20	1979	.52995	1864	.54242	1752	.55528	1644	.56857	1540	.58232	10
	1977	.53016	1862	.54263	1750	.55550	1642	.56880	1538	.58255	
21	1975	.53036	1860	.54284	1749	.55572	1641	.56902	1536	.58278	9
	1973	.53057	1858	.54305	1747	.55593	1639	.56925	1534	.58302	
22	1971	.53077	1856	.54326	1745	.55615	1637	.56947	1533	.58325	8
	1969	.53098	1854	.54347	1743	.55637	1635	.56970	1531	.58348	
23	1967	.53118	1853	.54368	1741	.55659	1634	.56992	1529	.58372	7
	1966	.53139	1851	.54390	1739	.55681	1632	.57015	1528	.58395	
24	1964	.53159	1849	.54411	1738	.55703	1630	.57038	1526	.58418	6
	1962	.53180	1847	.54432	1736	.55725	1628	.57060	1524	.58442	
25	1960	.53200	1845	.54453	1734	.55746	1627	.57083	1523	.58465	5
	1958	.53221	1843	.54474	1732	.55768	1625	.57106	1521	.58489	
26	1956	.53241	1841	.54496	1730	.55790	1623	.57128	1519	.58512	4
	1954	.53262	1839	.54517	1728	.55812	1621	.57151	1517	.58536	
27	1952	.53283	1837	.54538	1727	.55834	1619	.57174	1516	.58559	3
	1950	.53303	1836	.54559	1725	.55856	1618	.57196	1514	.58583	
28	1948	.53324	1834	.54581	1723	.55878	1616	.57219	1512	.58606	2
	1946	.53344	1832	.54602	1721	.55900	1614	.57242	1511	.58630	
29	1944	.53365	1830	.54623	1719	.55922	1612	.57265	1509	.58653	1
	1942	.53386	1828	.54644	1718	.55944	1611	.57287	1507	.58677	
30	1940	.53406	1826	.54666	1716	.55966	1609	.57310	1506	.58700	0
'	A	B	A	B	A	B	A	B	A	B	'
	107°00'		106°30'		106°00'		105°30'		105°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	75°00'		75°30'		76°00'		76°30'		77°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	1506	.58700	1406	.60140	1310	.61632	1217	.63181	1128	.64791	30
	1504	.58724	1404	.60164	1308	.61658	1215	.63208	1126	.64819	
1	1502	.58748	1403	.60189	1306	.61683	1214	.63234	1125	.64846	29
	1500	.58771	1401	.60213	1305	.61709	1212	.63260	1123	.64873	
2	1499	.58795	1399	.60238	1303	.61734	1211	.63287	1122	.64901	28
	1497	.58818	1398	.60262	1301	.61759	1209	.63313	1120	.64928	
3	1495	.58842	1396	.60287	1300	.61785	1208	.63340	1119	.64956	27
	1494	.58866	1394	.60311	1299	.61810	1206	.63366	1117	.64983	
4	1492	.58889	1393	.60335	1297	.61836	1205	.63392	1116	.65011	26
	1490	.58913	1391	.60360	1295	.61861	1203	.63419	1114	.65038	
5	1489	.58937	1390	.60385	1294	.61887	1202	.63445	1113	.65066	25
	1487	.58960	1388	.60410	1292	.61912	1200	.63472	1112	.65093	
6	1485	.58984	1386	.60434	1291	.61938	1199	.63498	1110	.65121	24
	1484	.59008	1385	.60459	1289	.61963	1197	.63525	1109	.65148	
7	1482	.59032	1383	.60483	1288	.61989	1196	.63551	1107	.65176	23
	1480	.59055	1381	.60508	1286	.62014	1194	.63578	1106	.65204	
8	1479	.59079	1380	.60533	1284	.62040	1193	.63605	1104	.65231	22
	1477	.59103	1378	.60557	1283	.62065	1191	.63631	1103	.65259	
9	1475	.59127	1377	.60582	1281	.62091	1190	.63658	1101	.65287	21
	1474	.59151	1375	.60607	1280	.62117	1188	.63684	1100	.65314	
10	1472	.59175	1373	.60631	1278	.62142	1187	.63711	1099	.65342	20
	1470	.59198	1372	.60656	1277	.62168	1185	.63738	1097	.65370	
11	1469	.59222	1370	.60681	1275	.62194	1184	.63764	1096	.65398	19
	1467	.59246	1368	.60706	1274	.62219	1182	.63791	1094	.65425	
12	1465	.59270	1367	.60730	1272	.62245	1181	.63818	1093	.65453	18
	1464	.59294	1365	.60755	1270	.62271	1179	.63845	1091	.65481	
13	1462	.59318	1364	.60780	1269	.62296	1178	.63871	1090	.65509	17
	1460	.59342	1362	.60805	1267	.62322	1176	.63898	1089	.65537	
14	1459	.59366	1360	.60830	1266	.62348	1175	.63925	1087	.65564	16
	1457	.59390	1359	.60855	1264	.62374	1173	.63952	1086	.65592	
15	1455	.59414	1357	.60879	1263	.62400	1172	.63978	1084	.65620	15
	1454	.59438	1356	.60904	1261	.62425	1170	.64005	1083	.65648	
16	1452	.59462	1354	.60929	1260	.62451	1169	.64032	1081	.65676	14
	1450	.59486	1352	.60954	1258	.62477	1167	.64059	1080	.65704	
17	1449	.59510	1351	.60979	1257	.62503	1166	.64086	1079	.65732	13
	1447	.59534	1349	.61004	1255	.62529	1164	.64113	1077	.65760	
18	1445	.59558	1348	.61029	1253	.62555	1163	.64140	1076	.65788	12
	1444	.59582	1346	.61054	1252	.62581	1161	.64167	1074	.65816	
19	1442	.59606	1344	.61079	1250	.62607	1160	.64194	1073	.65844	11
	1440	.59630	1343	.61104	1249	.62633	1158	.64221	1071	.65872	
20	1439	.59654	1341	.61129	1247	.62659	1157	.64248	1070	.65900	10
	1437	.59679	1340	.61154	1246	.62685	1155	.64275	1069	.65928	
21	1435	.59703	1338	.61179	1244	.62711	1154	.64302	1067	.65957	9
	1434	.59727	1336	.61204	1243	.62737	1152	.64329	1066	.65985	
22	1432	.59751	1335	.61229	1241	.62763	1151	.64356	1064	.66013	8
	1430	.59775	1333	.61254	1240	.62789	1150	.64383	1063	.66041	
23	1429	.59800	1332	.61279	1238	.62815	1148	.64410	1061	.66069	7
	1427	.59824	1330	.61304	1237	.62841	1147	.64437	1060	.66098	
24	1425	.59848	1329	.61330	1235	.62867	1145	.64464	1059	.66126	6
	1424	.59872	1327	.61355	1234	.62893	1144	.64491	1057	.66154	
25	1422	.59896	1325	.61380	1232	.62919	1142	.64518	1056	.66182	5
	1421	.59921	1324	.61405	1230	.62945	1141	.64546	1054	.66211	
26	1419	.59945	1322	.61430	1229	.62971	1139	.64573	1053	.66239	4
	1417	.59969	1321	.61456	1227	.62998	1138	.64600	1052	.66267	
27	1416	.59994	1319	.61481	1226	.63024	1136	.64627	1050	.66296	3
	1414	.60018	1317	.61506	1224	.63050	1135	.64655	1049	.66324	
28	1412	.60042	1316	.61531	1223	.63076	1133	.64682	1047	.66352	2
	1411	.60067	1314	.61556	1221	.63103	1132	.64709	1046	.66381	
29	1409	.60091	1313	.61582	1220	.63129	1130	.64736	1045	.66409	1
	1407	.60116	1311	.61607	1218	.63155	1129	.64764	1043	.66438	
30	1406	.60140	1310	.61632	1217	.63181	1128	.64791	1042	.66466	0
'	A	B	A	B	A	B	A	B	A	B	'
	104°30'		104°00'		103°30'		103°00'		102°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	77°30'		78°00'		78°30'		79°00'		79°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	1042	.66466	960	.68212	881	.70034	805	.71940	733	.73937	30
	1040	.66495	958	.68242	879	.70065	804	.71973	732	.73971	
1	1039	.66523	957	.68272	878	.70097	803	.72005	731	.74005	29
	1038	.66552	955	.68301	877	.70128	802	.72038	730	.74039	
2	1036	.66580	954	.68331	876	.70159	800	.72070	729	.74073	28
	1035	.66609	953	.68361	874	.70190	799	.72103	728	.74107	
3	1033	.66638	951	.68391	873	.70221	798	.72136	726	.74142	27
	1032	.66666	950	.68421	872	.70252	797	.72168	725	.74176	
4	1031	.66695	949	.68450	870	.70284	796	.72201	724	.74210	26
	1029	.66724	947	.68480	869	.70315	794	.72234	723	.74245	
5	1028	.66752	946	.68510	868	.70346	793	.72266	722	.74279	25
	1026	.66781	945	.68540	867	.70377	792	.72299	721	.74313	
6	1025	.66810	943	.68570	865	.70409	791	.72332	719	.74348	24
	1024	.66838	942	.68600	864	.70440	790	.72365	718	.74382	
7	1022	.66867	941	.68630	863	.70471	788	.72397	717	.74417	23
	1021	.66896	939	.68660	862	.70503	787	.72430	716	.74451	
8	1020	.66925	938	.68690	860	.70534	786	.72463	715	.74486	22
	1018	.66953	937	.68720	859	.70566	785	.72496	714	.74520	
9	1017	.66982	935	.68750	858	.70597	783	.72529	712	.74555	21
	1015	.67011	934	.68781	856	.70629	782	.72562	711	.74589	
10	1014	.67040	933	.68811	855	.70660	781	.72595	710	.74624	20
	1013	.67069	932	.68841	854	.70692	780	.72628	709	.74659	
11	1011	.67098	930	.68871	853	.70723	779	.72661	708	.74693	19
	1010	.67127	929	.68901	851	.70755	777	.72694	707	.74728	
12	1008	.67156	928	.68931	850	.70786	776	.72727	706	.74763	18
	1007	.67185	926	.68962	849	.70818	775	.72760	704	.74797	
13	1006	.67214	925	.68992	848	.70850	774	.72794	703	.74832	17
	1004	.67243	924	.69022	846	.70881	772	.72827	702	.74867	
14	1003	.67272	922	.69053	845	.70913	771	.72860	701	.74902	16
	1002	.67301	921	.69083	844	.70945	770	.72893	700	.74937	
15	1000	.67330	920	.69113	843	.70976	769	.72926	699	.74972	15
	999	.67359	918	.69144	841	.71008	768	.72960	698	.75007	
16	997	.67388	917	.69174	840	.71040	767	.72993	696	.75042	14
	996	.67417	916	.69204	839	.71072	765	.73026	695	.75077	
17	995	.67447	914	.69235	838	.71104	764	.73060	694	.75112	13
	993	.67476	913	.69265	836	.71135	763	.73093	693	.75147	
18	992	.67505	912	.69296	835	.71167	762	.73127	692	.75182	12
	991	.67534	910	.69326	834	.71199	761	.73160	691	.75217	
19	989	.67563	909	.69357	833	.71231	759	.73193	690	.75252	11
	988	.67593	908	.69387	831	.71263	758	.73227	688	.75287	
20	987	.67622	907	.69418	830	.71295	757	.73260	687	.75322	10
	985	.67651	905	.69449	829	.71327	756	.73294	686	.75358	
21	984	.67681	904	.69479	828	.71359	755	.73328	685	.75393	9
	982	.67710	903	.69510	826	.71391	753	.73361	684	.75428	
22	981	.67739	901	.69541	825	.71423	752	.73395	683	.75464	8
	980	.67769	900	.69571	824	.71455	751	.73429	682	.75499	
23	978	.67798	899	.69602	823	.71488	750	.73462	680	.75534	7
	977	.67828	897	.69633	821	.71520	749	.73496	679	.75570	
24	976	.67857	896	.69664	820	.71552	747	.73530	678	.75605	6
	974	.67886	895	.69694	819	.71584	746	.73563	677	.75641	
25	973	.67916	894	.69725	818	.71616	745	.73597	676	.75676	5
	972	.67945	892	.69756	816	.71649	744	.73631	675	.75712	
26	970	.67975	891	.69787	815	.71681	743	.73665	674	.75747	4
	969	.68005	890	.69815	814	.71713	742	.73699	673	.75783	
27	968	.68034	888	.69849	813	.71746	740	.73733	672	.75819	3
	966	.68064	887	.69879	811	.71778	739	.73767	670	.75854	
28	965	.68093	886	.69910	810	.71810	738	.73801	669	.75890	2
	964	.68123	885	.69941	809	.71843	737	.73835	668	.75926	
29	962	.68153	883	.69972	808	.71875	736	.73869	667	.75961	1
	961	.68182	882	.70003	807	.71908	735	.73903	666	.75997	
30	960	.68212	881	.70034	805	.71940	733	.73937	665	.76033	0
'	A	B	A	B	A	B	A	B	A	B	'
	102°00'		101°30'		101°00'		100°30'		100°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	80°00'		80°30'		81°00'		81°30'		82°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	665	.76033	600	.78239	538	.80567	480	.83030	425	.85644	30
	664	.76069	599	.78277	537	.80607	479	.83072	424	.85689	
1	663	.76105	598	.78315	536	.80647	478	.83114	423	.85734	29
	661	.76141	597	.78352	535	.80687	477	.83157	422	.85779	
2	660	.76176	595	.78390	534	.80727	476	.83199	421	.85825	28
	659	.76212	594	.78428	533	.80767	475	.83242	420	.85870	
3	658	.76248	593	.78466	532	.80807	474	.83284	419	.85915	27
	657	.76284	592	.78504	531	.80847	473	.83327	418	.85960	
4	656	.76320	591	.78542	530	.80887	472	.83369	418	.86006	26
	655	.76357	590	.78580	529	.80927	471	.83412	417	.86051	
5	654	.76393	589	.78618	528	.80967	470	.83455	416	.86096	25
	653	.76429	588	.78656	527	.81008	469	.83497	415	.86142	
6	652	.76465	587	.78694	526	.81048	468	.83540	414	.86187	24
	650	.76501	586	.78733	525	.81088	467	.83583	413	.86233	
7	649	.76537	585	.78771	524	.81129	467	.83626	412	.86278	23
	648	.76574	584	.78809	523	.81169	466	.83668	411	.86324	
8	647	.76610	583	.78847	522	.81210	465	.83711	411	.86370	22
	646	.76646	582	.78886	521	.81250	464	.83754	410	.86415	
9	645	.76683	581	.78924	520	.81291	463	.83797	409	.86461	21
	644	.76719	580	.78962	519	.81331	462	.83840	408	.86507	
10	643	.76756	579	.79001	518	.81372	461	.83884	407	.86553	20
	642	.76792	578	.79039	517	.81413	460	.83927	406	.86599	
11	641	.76828	577	.79078	516	.81453	459	.83970	405	.86645	19
	639	.76865	576	.79116	515	.81494	458	.84013	405	.86691	
12	638	.76902	575	.79155	514	.81535	457	.84056	404	.86737	18
	637	.76938	574	.79193	513	.81576	456	.84100	403	.86783	
13	636	.76975	573	.79232	512	.81617	455	.84143	402	.86829	17
	635	.77011	571	.79271	511	.81657	454	.84186	401	.86876	
14	634	.77048	570	.79309	510	.81698	454	.84230	400	.86922	16
	633	.77085	569	.79348	509	.81739	453	.84273	399	.86968	
15	632	.77122	568	.79387	508	.81780	452	.84317	399	.87015	15
	631	.77158	567	.79426	507	.81821	451	.84361	398	.87061	
16	630	.77195	566	.79465	506	.81863	450	.84404	397	.87107	14
	629	.77232	565	.79503	505	.81904	449	.84448	396	.87154	
17	627	.77269	564	.79542	504	.81945	448	.84492	395	.87201	13
	626	.77306	563	.79581	504	.81986	447	.84535	394	.87247	
18	625	.77343	562	.79620	503	.82027	446	.84579	393	.87294	12
	624	.77380	561	.79659	502	.82069	445	.84623	392	.87341	
19	623	.77417	560	.79698	501	.82110	444	.84667	392	.87387	11
	622	.77454	559	.79737	500	.82151	444	.84711	391	.87434	
20	621	.77491	558	.79777	499	.82193	443	.84755	390	.87481	10
	620	.77528	557	.79816	498	.82234	442	.84799	389	.87528	
21	619	.77565	556	.79855	497	.82276	441	.84843	388	.87575	9
	618	.77602	555	.79894	496	.82317	440	.84887	387	.87622	
22	617	.77639	554	.79933	495	.82359	439	.84931	387	.87669	8
	616	.77677	553	.79973	494	.82400	438	.84976	386	.87716	
23	615	.77714	552	.80012	493	.82442	437	.85020	385	.87764	7
	614	.77751	551	.80051	492	.82484	436	.85064	384	.87811	
24	612	.77788	550	.80091	491	.82526	435	.85109	383	.87858	6
	611	.77826	549	.80130	490	.82567	434	.85153	382	.87906	
25	610	.77863	548	.80170	489	.82609	434	.85197	381	.87953	5
	609	.77901	547	.80209	488	.82651	433	.85242	381	.88001	
26	608	.77938	546	.80249	487	.82693	432	.85286	380	.88048	4
	607	.77976	545	.80288	486	.82735	431	.85331	379	.88096	
27	606	.78013	544	.80328	485	.82777	430	.85376	378	.88143	3
	605	.78051	543	.80368	484	.82819	429	.85420	377	.88191	
28	604	.78088	542	.80407	483	.82861	428	.85465	376	.88239	2
	603	.78126	541	.80447	482	.82903	427	.85510	376	.88286	
29	602	.78164	540	.80487	482	.82945	426	.85555	375	.88334	1
	601	.78201	539	.80527	481	.82987	426	.85599	374	.88382	
30	600	.78239	538	.80567	480	.83030	425	.85644	373	.88430	0
'	A	B	A	B	A	B	A	B	A	B	'
	99°30'		99°00'		98°30'		98°00'		97°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	82°30'		83°00'		83°30'		84°00'		84°30'		
'	A	B	A	B	A	B	A	B	A	B	'
0	373	.88430	325	.91411	280	.94614	238.6	.98076	200.4	101843	30
	372	.88478	324	.91462	279	.94670	237.9	.98137	199.8	101908	
1	371	.88526	323	.91514	279	.94725	237.2	.98197	199.2	101974	29
	371	.88574	323	.91565	278	.94781	236.6	.98257	198.6	102040	
2	370	.88623	322	.91617	277	.94836	235.9	.98318	198.0	102106	28
	369	.88671	321	.91668	276	.94892	235.3	.98378	197.4	102172	
3	368	.88719	320	.91720	276	.94948	234.6	.98439	196.8	102238	27
	367	.88767	319	.91772	275	.95004	233.9	.98499	196.2	102304	
4	366	.88816	319	.91824	274	.95060	233.3	.98560	195.6	102371	26
	366	.88864	318	.91876	274	.95116	232.6	.98621	195.0	102437	
5	365	.88913	317	.91928	273	.95172	232.0	.98682	194.4	102504	25
	364	.88961	316	.91980	272	.95228	231.3	.98743	193.8	102570	
6	363	.89010	316	.92032	271	.95285	230.7	.98804	193.2	102637	24
	362	.89059	315	.92085	271	.95341	230.0	.98865	192.6	102704	
7	362	.89107	314	.92137	270	.95397	229.4	.98926	192.0	102771	23
	361	.89156	313	.92189	269	.95454	228.7	.98988	191.4	102838	
8	360	.89205	313	.92242	269	.95510	228.1	.99049	190.8	102905	22
	359	.89254	312	.92294	268	.95567	227.4	.99111	190.2	102973	
9	358	.89303	311	.92347	267	.95624	226.8	.99172	189.6	103040	21
	357	.89352	310	.92399	267	.95681	226.1	.99234	189.0	103107	
10	357	.89401	310	.92452	266	.95737	225.5	.99296	188.4	103175	20
	356	.89450	309	.92505	265	.95795	224.8	.99357	187.8	103243	
11	355	.89499	308	.92558	264	.95851	224.2	.99419	187.2	103311	19
	354	.89548	307	.92610	264	.95909	223.5	.99482	186.7	103379	
12	353	.89597	307	.92663	263	.95966	222.9	.99544	186.1	103447	18
	353	.89647	306	.92716	262	.96023	222.3	.99606	185.5	103515	
13	352	.89696	305	.92769	262	.96080	221.6	.99668	184.9	103583	17
	351	.89746	304	.92823	261	.96138	221.0	.99731	184.3	103651	
14	350	.89795	304	.92876	260	.96195	220.3	.99793	183.7	103720	16
	349	.89845	303	.92929	260	.96253	219.7	.99856	183.2	103788	
15	349	.89894	302	.92982	259	.96310	219.1	.99918	182.6	103857	15
	348	.89944	301	.93036	258	.96368	218.4	.99981	182.0	103926	
16	347	.89994	301	.93089	257	.96426	217.8	100044	181.4	103995	14
	346	.90044	300	.93143	257	.96484	217.2	100107	180.8	104064	
17	345	.90093	299	.93196	256	.96542	216.5	100170	180.3	104133	13
	345	.90143	298	.93250	255	.96600	215.9	100233	179.7	104202	
18	344	.90193	298	.93304	255	.96658	215.3	100296	179.1	104272	12
	343	.90243	297	.93358	254	.96716	214.6	100360	178.5	104341	
19	342	.90293	296	.93411	253	.96774	214.0	100423	178.0	104411	11
	341	.90344	295	.93465	253	.96833	213.4	100487	177.4	104480	
20	341	.90394	295	.93519	252	.96891	212.8	100550	176.8	104550	10
	340	.90444	294	.93573	251	.96950	212.1	100614	176.2	104620	
21	339	.90494	293	.93628	251	.97008	211.5	100678	175.7	104690	9
	338	.90545	292	.93682	250	.97067	210.9	100742	175.1	104760	
22	337	.90595	292	.93736	249	.97126	210.3	100806	174.5	104830	8
	337	.90646	291	.93790	249	.97184	209.6	100870	174.0	104901	
23	336	.90696	290	.93845	248	.97243	209.0	100934	173.4	104971	7
	335	.90747	289	.93899	247	.97302	208.4	100998	172.8	105042	
24	334	.90798	289	.93954	247	.97361	207.8	101063	172.3	105113	6
	333	.90848	288	.94009	246	.97420	207.1	101127	171.7	105183	
25	333	.90899	287	.94063	245	.97480	206.5	101192	171.1	105254	5
	332	.90950	287	.94118	245	.97539	205.9	101256	170.6	105325	
26	331	.91001	286	.94173	244	.97598	205.3	101321	170.0	105397	4
	330	.91052	285	.94228	243	.97658	204.7	101386	169.5	105468	
27	330	.91103	284	.94283	243	.97717	204.1	101451	168.9	105539	3
	329	.91154	284	.94338	242	.97777	203.5	101516	168.4	105611	
28	328	.91205	283	.94393	241	.97837	202.8	101581	167.8	105683	2
	327	.91257	282	.94448	241	.97897	202.2	101646	167.2	105754	
29	326	.91308	281	.94503	240	.97957	201.6	101712	166.7	105826	1
	326	.91359	281	.94559	239	.98017	201.0	101777	166.0	105898	
30	325	.91411	280	.94614	239	.98076	200.4	101843	165.6	105970	0
'	A	B	A	B	A	B	A	B	A	B	'
	97°00'		96°30'		96°00'		95°30'		95°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	85°00'		85°30'		86°00'		86°30'		87°00'		
'	A	B	A	B	A	B	A	B	A	B	'
0	165.6	105970	134.1	110536	105.9	115641	81.1	121432	59.6	128120	30
	165.0	106043	133.6	110616	105.5	115732	80.7	121536	59.2	128241	
1	164.5	106115	133.1	110696	105.0	115823	80.3	121639	58.9	128362	29
	163.9	106187	132.6	110777	104.6	115913	79.9	121743	58.6	128483	
2	163.4	106260	132.1	110858	104.2	116004	79.5	121848	58.2	128605	28
	162.8	106333	131.6	110939	103.7	116096	79.2	121952	57.9	128727	
3	162.3	106406	131.1	111020	103.3	116187	78.8	122057	57.6	128849	27
	161.7	106479	130.6	111101	102.9	116278	78.4	122161	57.3	128972	
4	161.2	106552	130.1	111183	102.4	116370	78.0	122267	56.9	129095	26
	160.6	106625	129.6	111264	102.0	116462	77.6	122372	56.6	129218	
5	160.1	106698	129.2	111346	101.6	116554	77.3	122478	56.3	129342	25
	159.6	106772	128.7	111428	101.1	116647	76.9	122584	56.0	129466	
6	159.0	106846	128.2	111510	100.7	116739	76.5	122690	55.7	129591	24
	158.5	106919	127.7	111592	100.3	116832	76.1	122796	55.3	129716	
7	157.9	106993	127.2	111674	99.8	116925	75.8	122903	55.0	129841	23
	157.4	107067	126.7	111757	99.4	117018	75.4	123010	54.7	129967	
8	156.9	107141	126.2	111839	99.0	117112	75.0	123117	54.4	130093	22
	156.3	107216	125.8	111922	98.5	117205	74.6	123225	54.1	130219	
9	155.8	107290	125.3	112005	98.1	117299	74.3	123332	53.7	130346	21
	155.2	107364	124.8	112088	97.7	117393	73.9	123441	53.4	130473	
10	154.7	107439	124.3	112171	97.3	117487	73.5	123549	53.1	130600	20
	154.2	107514	123.8	112255	96.8	117581	73.2	123657	52.8	130728	
11	153.6	107589	123.4	112338	96.4	117676	72.8	123766	52.5	130856	19
	153.1	107664	122.9	112422	96.0	117771	72.4	123875	52.2	130985	
12	152.6	107739	122.4	112506	95.6	117866	72.1	123985	51.9	131114	18
	152.1	107814	121.9	112590	95.2	117961	71.7	124095	51.6	131243	
13	151.5	107890	121.5	112674	94.7	118056	71.3	124204	51.3	131373	17
	151.0	107965	121.0	112759	94.3	118152	71.0	124315	51.0	131503	
14	150.5	108041	120.5	112843	93.9	118248	70.6	124425	50.7	131633	16
	149.9	108117	120.1	112928	93.5	118344	70.3	124536	50.3	131764	
15	149.4	108193	119.6	113013	93.1	118440	69.9	124647	50.0	131896	15
	148.9	108269	119.1	113098	92.7	118537	69.5	124759	49.7	132027	
16	148.4	108345	118.7	113183	92.3	118633	69.2	124870	49.4	132159	14
	147.8	108421	118.2	113269	91.8	118730	68.8	124982	49.1	132292	
17	147.3	108498	117.7	113354	91.4	118827	68.5	125094	48.8	132425	13
	146.8	108574	117.3	113440	91.0	118925	68.1	125207	48.5	132558	
18	146.3	108651	116.8	113526	90.6	119022	67.8	125320	48.2	132692	12
	145.8	108728	116.3	113612	90.2	119120	67.4	125433	47.9	132826	
19	145.2	108805	115.9	113699	89.8	119218	67.1	125546	47.6	132961	11
	144.7	108882	115.4	113785	89.4	119316	66.7	125660	47.3	133096	
20	144.2	108960	114.9	113872	89.0	119415	66.4	125774	47.1	133231	10
	143.7	109037	114.5	113958	88.6	119513	66.0	125888	46.8	133367	
21	143.2	109115	114.0	114045	88.2	119612	65.7	126003	46.5	133503	9
	142.7	109192	113.6	114133	87.8	119711	65.3	126118	46.2	133640	
22	142.2	109270	113.1	114220	87.4	119811	65.0	126233	45.9	133777	8
	141.6	109348	112.7	114307	87.0	119910	64.6	126349	45.6	133914	
23	141.1	109426	112.2	114395	86.6	120010	64.3	126465	45.3	134052	7
	140.6	109505	111.7	114483	86.2	120110	63.9	126581	45.0	134191	
24	140.1	109583	111.3	114571	85.8	120211	63.6	126697	44.7	134330	6
	139.6	109662	110.8	114659	85.4	120311	63.3	126814	44.4	134469	
25	139.1	109740	110.4	114747	85.0	120412	62.9	126931	44.2	134609	5
	138.6	109819	109.9	114836	84.6	120513	62.6	127049	43.9	134749	
26	138.1	109898	109.5	114925	84.2	120614	62.2	127166	43.6	134890	4
	137.6	109978	109.0	115014	83.8	120715	61.9	127284	43.3	135031	
27	137.1	110057	108.6	115103	83.4	120817	61.6	127403	43.0	135173	3
	136.6	110136	108.1	115192	83.0	120919	61.2	127521	42.7	135315	
28	136.1	110216	107.7	115282	82.6	121021	60.9	127640	42.5	135457	2
	135.6	110296	107.3	115371	82.2	121124	60.6	127760	42.2	135600	
29	135.1	110375	106.8	115461	81.9	121226	60.2	127880	41.9	135744	1
	134.6	110455	106.4	115551	81.5	121329	59.9	128000	41.6	135888	
30	134.1	110536	105.9	115641	81.1	121432	59.6	128120	41.4	136032	0
'	A	B	A	B	A	B	A	B	A	B	'
	94°30'		94°00'		93°30'		93°00'		92°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	87°30'		88°00'		88°30'		89°00'		89°30'		
	A	B	A	B	A	B	A	B	A	B	
0	41.4	136032	26.5	145718	14.9	158208	6.6	175814	1.7	205916	30
	41.1	136177	26.2	145899	14.7	158450	6.5	176178	1.6	206646	
1	40.8	136322	26.0	146081	14.6	158693	6.4	176544	1.5	207388	29
	40.5	136468	25.8	146264	14.4	158938	6.3	176914	1.5	208143	
2	40.3	136615	25.6	146448	14.2	159184	6.2	177287	1.4	208912	28
	40.0	136761	25.4	146632	14.1	159431	6.1	177663	1.4	209695	
3	39.7	136909	25.2	146817	13.9	159680	6.0	178042	1.3	210491	27
	39.4	137057	24.9	147003	13.7	159930	5.9	178424	1.3	211303	
4	39.2	137205	24.7	147190	13.6	160182	5.8	178810	1.2	212130	26
	38.9	137354	24.5	147377	13.4	160435	5.7	179200	1.2	212974	
5	38.6	137503	24.3	147566	13.3	160690	5.6	179593	1.1	213834	25
	38.4	137653	24.1	147755	13.1	160946	5.5	179990	1.1	214711	
6	38.1	137804	23.9	147945	13.0	161204	5.4	180390	1.1	215607	24
	37.8	137955	23.7	148135	12.8	161463	5.3	180794	1.0	216521	
7	37.6	138106	23.5	148327	12.7	161724	5.2	181201	1.0	217455	23
	37.3	138258	23.3	148520	12.5	161986	5.1	181613	0.9	218409	
8	37.1	138411	23.1	148713	12.4	162250	5.0	182029	0.9	219385	22
	36.8	138564	22.8	148907	12.2	162516	4.9	182448	0.9	220384	
9	36.5	138718	22.6	149103	12.1	162783	4.8	182872	0.8	221406	21
	36.3	138872	22.4	149299	11.9	163052	4.7	183300	0.8	222452	
10	36.0	139027	22.2	149495	11.8	163322	4.6	183732	0.7	223525	20
	35.8	139182	22.0	149693	11.6	163594	4.5	184168	0.7	224624	
11	35.5	139338	21.8	149892	11.5	163868	4.4	184609	0.7	225752	19
	35.3	139494	21.6	150092	11.3	164144	4.3	185055	0.6	226910	
12	35.0	139651	21.4	150292	11.2	164422	4.2	185505	0.6	228100	18
	34.7	139809	21.2	150494	11.0	164701	4.1	185959	0.6	229324	
13	34.5	139967	21.0	150696	10.9	164982	4.1	186419	0.5	230583	17
	34.2	140125	20.8	150899	10.8	165265	4.0	186883	0.5	231879	
14	34.0	140285	20.6	151104	10.6	165550	3.9	187353	0.5	233215	16
	33.7	140445	20.5	151309	10.5	165836	3.8	187827	0.4	234594	
15	33.5	140605	20.3	151515	10.3	166125	3.7	188307	0.4	236018	15
	33.2	140766	20.1	151722	10.2	166415	3.6	188793	0.4	237491	
16	33.0	140928	19.9	151931	10.1	166708	3.6	189283	0.4	239015	14
	32.8	141090	19.7	152140	9.9	167002	3.5	189780	0.3	240594	
17	32.5	141253	19.5	152350	9.8	167298	3.4	190282	0.3	242233	13
	32.3	141417	19.3	152561	9.7	167597	3.3	190790	0.3	243936	
18	32.0	141581	19.1	152774	9.5	167897	3.2	191303	0.3	245709	12
	31.8	141745	18.9	152987	9.4	168200	3.2	191824	0.2	247558	
19	31.5	141911	18.7	153201	9.3	168505	3.1	192350	0.2	249488	11
	31.3	142077	18.6	153417	9.1	168811	3.0	192883	0.2	251508	
20	31.1	142243	18.4	153633	9.0	169121	2.9	193422	0.2	253627	10
	30.8	142411	18.2	153851	8.9	169432	2.9	193969	0.2	255855	
21	30.6	142579	18.0	154070	8.7	169745	2.8	194522	0.1	258203	9
	30.4	142747	17.8	154290	8.6	170061	2.7	195082	0.1	260685	
22	30.1	142916	17.6	154511	8.5	170379	2.7	195650	0.1	263318	8
	29.9	143086	17.5	154733	8.4	170700	2.6	196225	0.1	266121	
23	29.6	143257	17.3	154956	8.2	171023	2.5	196808	0.1	269118	7
	29.4	143428	17.1	155180	8.1	171348	2.4	197399	0.1	272336	
24	29.2	143600	16.9	155406	8.0	171676	2.4	197998	0.1	275812	6
	28.9	143773	16.8	155633	7.9	172006	2.3	198605	0.1	279591	
25	28.7	143946	16.6	155861	7.8	172339	2.3	199221	0.0	283730	5
	28.5	144120	16.4	156090	7.6	172674	2.2	199846	0.0	288306	
26	28.3	144295	16.2	156320	7.5	173012	2.1	200480	0.0	293421	4
	28.0	144470	16.1	156552	7.4	173352	2.1	201124	0.0	299221	
27	27.8	144646	15.9	156784	7.3	173696	2.0	201777	0.0	305915	3
	27.6	144823	15.7	157019	7.2	174042	1.9	202440	0.0	313833	
28	27.4	145000	15.6	157254	7.1	174391	1.9	203113	0.0	323524	2
	27.1	145179	15.4	157490	6.9	174742	1.8	203797	0.0	336018	
29	26.9	145358	15.2	157728	6.8	175097	1.8	204492	0.0	353627	1
	26.7	145538	15.1	157967	6.7	175454	1.7	205198	0.0	383730	
30	26.5	145718	14.9	158208	6.6	175814	1.7	205916	0.0	....	0
	A	B	A	B	A	B	A	B	A	B	
	92°00'		91°30'		91°00'		90°30'		90°00		

GLOSSARY

A

Amplification—The process of increasing the electrical strength of a signal.

Antenna—An electrical conductor or a system of conductors used to radiate or receive radio waves.

Array (Antenna)—An arrangement of antenna elements to achieve desirable directional characteristics.

B

Basepoint—Any point on the earth's surface whose exact location is known by grid coordinates and over which (while airborne) accuracy adjustments to Doppler radar navigational systems may be made.

Bearing—The angular measurement in degrees from true north of an arriving radio wave with relation to the DF site. A bearing is often called a "shot."

Bidirectional—Responsive in two opposite directions. An ordinary loop antenna is bidirectional because it has maximum response from the two opposite directions that are in the plane of the loop.

C

Checkpoint—The exact location of an ARDF aircraft over the ground, identified by grid coordinates, when a DF bearing is obtained from that aircraft.

Coaxial cable—A transmission line consisting of two conductors, one inside the other, and separated by insulating material. The inner conductor may be a small copper tube or wire; the outer conductor may be metallic tubing or braid. Radiation loss from this type of line is practically zero. Coaxial cable is also called concentric line.

Conductivity—The relative ability of a material to allow the flow or passage of an electrical current.

Counterpoise—(1) A system of wires and other conductors that is elevated above and insulated from the ground to form a lower system of conductors for a transceiver antenna. (2) A system which is electrically connected to earth and positioned beneath receiving antenna elements, such as the wire mesh screens used with the AN/TRD–15 direction finder set.

Critical angle—The smallest angle from the vertical at which a radiated wave of a given frequency will still be reflected by the ionosphere. At smaller angles the radio waves penetrate the ionosphere and are not returned to earth.

Cut—The point of intersection of two DF bearings.

D

Dead reckoning—Determination of the approximate position of a vehicle by combining vectors for speed, direction, and other factors with the last known position.

Directional antenna—An antenna which radiates or receives radio waves more effectively in some directions than others. The term is usually applied to antennas whose directivity is greater than that of a half-wave dipole.

DF fix—The probable location of a target transmitter's antenna when three or more DF bearings have been plotted on a chart or map. Sometimes called a fix area.

DF plot (plotting)—The placing of DF bearings on a chart or map so that a target's location can be determined by reference to grid coordinates.

Direct path—A path that has no intervening obstacles and is said to be line-of-sight.

E

E region—The region of the ionosphere, between about 88 and 156 kilometers above the surface of the earth, that contains ionized layers capable of bending (reflecting or refracting) radio waves.

Electromagnetic field—The magnetic field that an electric current produces around the conductor through which it flows.

F

F region—The region of the ionosphere between about 200 and 310 kilometers above the earth's surface.

F1 layer—One of the regular ionospheric layers at an average height of about 225 kilometers which occurs during the daylight hours.

F2 layer—The most useful of the ionospheric layers for radio wave propagation. It is the most highly ionized and highest of the layers, having an average height of 225 kilometers and a midday height of about 400 kilometers.

Fading—Variations in the strength of a received radio signal caused by changes in the characteristics of the propagation or transmission medium.

Frequency—The number of complete cycles per second (Hertz) existing in any form of electrical or sound wave motions.

G

Goniometer—An instrument for measuring angles. Used to calculate and resolve mathematical problems or electrical functions as well as to establish direction phase difference between transmitted or received signals.

Great circle—Any circle described on the surface of the earth or other sphere so that its plane passes through the center of the sphere. Radio waves follow great-circle routes in their passage around the earth.

H

Hop—The path of a radio wave from the earth to the ionosphere and back to earth, in traveling from one point to another. It is usually used in expressions such as single hop, double hop, and multihop. The number of hops is called the order of reflection.

I

Indirect path—Any path, other than a direct path, between two stations.

Interference—Any electrical disturbance from a different source which causes undesirable responses in electronic equipment.

O

Octantal error—The erroneous reading of an arriving signal caused by the nonuniformity of the flux fields within the stationary winding of a goniometer (when used in DF sites).

P

Path—That part of the atmosphere through which the radiated wave passes.

Polarity—An electrical condition determining the direction in which current tends to flow. By common usage, the discharge current is said to flow from the positive electrode through the external circuit.

Polarization—The direction of the electrical field component of radiated energy.

R

Radiate—To send out energy into space, as in the case of RF waves.

S

Siting—Properly locating an antenna, radio set, or DF set to obtain optimum performance.

Skip distance—The minimum separation at which radio waves of a specified frequency can be transmitted at a specified time between two points on the earth by reflection from the regular ionized layers of the ionosphere.

Skywave—A radio wave that reaches the receiving station after returning from the ionosphere (as distinguished from groundwave).

W

Winding—One or more turns of wire forming a continuous coil for a transformer, relay, rotating machine, antenna, or other electrical device.

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8 APRIL 1977

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief of Staff

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PAUL T. SMITH
Major General, United States Army
The Adjutant General

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